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REVIEW AND RECOMMENDATIONS FOR THE INTERAGENCY SHIP STRUCTURE C--ETC(U)
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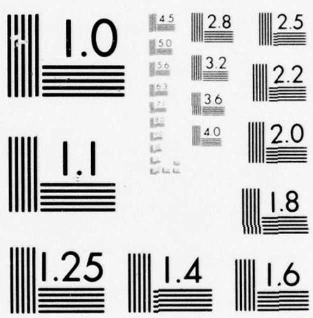

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NATIONAL BUREAU OF STANDARDS-1963-A

Review and Recommendations for the Interagency Ship Structure Committee's Fiscal 1978 Research Program

Ship Research Committee

Maritime Transportation Research Board

Commission on Sociotechnical Systems

MARITIME TRANSPORTATION RESEARCH BOARD

Commission on Sociotechnical Systems

National Academy of Sciences -- National Research Council

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SHIP RESEARCH COMMITTEE

The Ship Research Committee of the Maritime Transportation Research Board, provides technical advice to the Ship Structure Committee, on design and fabrication of ships and on materials used in their construction. The advisory program comprises research projects with short, intermediate, and long-range goals. The members of the Committee are:

REVIEW AND RECOMMENDATIONS

for the

INTERAGENCY

SHIP STRUCTURE COMMITTEE'S

FISCAL 1978 RESEARCH PROGRAM

A Report Prepared

by the

SHIP RESEARCH COMMITTEE

of the

Maritime Transportation Research Board

Commission on Sociotechnical Systems

National Research Council

National Academy of Sciences
Washington, D.C.

March 1977

See 1473

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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This study was sponsored by the interagency Ship Structure Committee, consisting of representatives from the Military Sealift Command, the U.S. Coast Guard, the Naval Sea Systems Command, the Maritime Administration, and the American Bureau of Shipping, and is submitted to the Commandant, U.S. Coast Guard, under provisions of Contract DOT-CG-70387-A between the National Academy of Sciences and the Commandant, U.S. Coast Guard, acting for the Ship Structure Committee.

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CONTENTS

ABSTRACT

The Ship Research Committee of the National Research Council provides technical services to the interagency Ship Structure Committee with regard to program recommendations, proposal evaluations, and project advice. This requires continuing interaction to assure an effective program to improve ship hull structures through an extension of knowledge of design, materials and methods of fabrication, with full consideration of both static and dynamic loading and response. This report contains the Ship Research Committee's recommended research program for five years, FY 1977 - 1981, with 14 specific prospectuses from which to select projects for FY 1978. Also included is a brief review of 24 active and three recently completed projects.

SHIP RESEARCH COMMITTEE'S ADVISORY GROUPS

SHIP DESIGN, RESPONSE, AND LOAD CRITERIA ADVISORY GROUP

Mr. D. P. Roseman, Chairman, *Chief Naval Architect, Hydronautics, Inc.*
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Prof. J. H. Williams, Jr., *Dept. of Mech. Engrg., Mass. Inst. of Technology*

SHIP STRUCTURE COMMITTEE

The SHIP STRUCTURE COMMITTEE is constituted to prosecute a research program to improve the hull structures of ships by an extension of knowledge pertaining to design, materials and methods of fabrication.

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Chief, Office of Merchant Marine Safety
U.S. Coast Guard Headquarters

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Asst. for Structures
Naval Ship Engineering Center
Naval Ship Systems Command

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Vice President
American Bureau of Shipping

Mr. M. Pitkin
Asst. Administrator for
Commercial Development
Maritime Administration

Mr. C. J. Whitestone
Engineer Officer
Military Sealift Command

SHIP STRUCTURE SUBCOMMITTEE

The SHIP STRUCTURE SUBCOMMITTEE acts for the Ship Structure Committee on technical matters by providing technical coordination for the determination of goals and objectives of the program, and by evaluating and interpreting the results in terms of ship structural design, construction and operation.

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INTRODUCTION

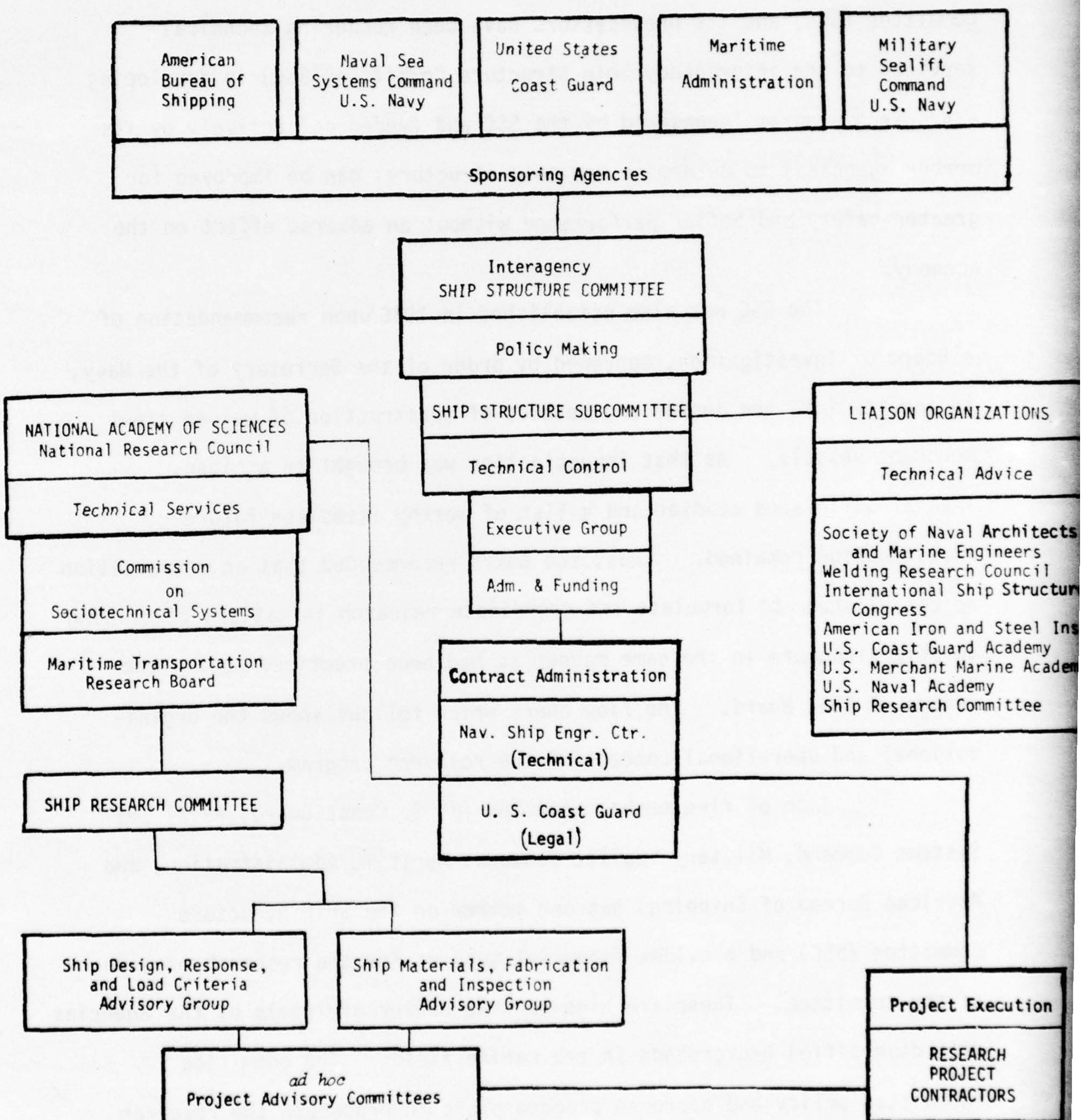
Since 1946, the National Research Council's Ship Research Committee (SRC) and its predecessors have been rendering technical services to the interagency Ship Structure Committee (SSC) in developing a research program (sponsored by the SSC and funded collectively by its member agencies) to determine how ship structures can be improved for greater safety and better performance without an adverse effect on the economy.

The SSC was also established in 1946 upon recommendation of a Board of Investigation, convened by order of the Secretary of the Navy, to inquire into the design and methods of construction of welded steel merchant vessels. As that investigation was brought to a close, several unfinished studies and a list of worthy items for future investigation remained. Thus, the Board recommended that an organization be established to formulate and coordinate research in matters pertaining to ship structure in the same manner as had been practiced during the tenure of that Board. The flow chart which follows shows the organizational and operational concept of the research program.

Each of five member agencies (U. S. Coast Guard, Naval Sea Systems Command, Military Sealift Command, Maritime Administration, and American Bureau of Shipping) has one member on the Ship Structure Committee (SSC) and provides financial support for the research program of the committee. These are high-ranking senior officials of the agencies with diversified backgrounds in the marine field. The committee formulates policy and approves program plans to prosecute the research program.

Working for this policy-making body is the Ship Structure Subcommittee (SSSC). This Subcommittee acts on technical matters to

SHIP STRUCTURE COMMITTEE ORGANIZATION CHART



assure the achievement of the goals and objectives of the program and by evaluating and interpreting the results in terms of ship structural design, construction and operation. All Subcommittee meetings are attended by members from each of the five member agencies and by liaison members. Working with the technical services of the Ship Research Committee of the National Research Council, research needs are met by the SSC contracting with the firms deemed capable of carrying out the work through the U.S. Coast Guard.

The SRC, with advice and aid of its Ship Design, Response, and Load Criteria Advisory Group, and its Ship Materials, Fabrication, and Inspection Advisory Group, performs the following services in connection with the SSC research program:

a) assists and advises in setting specific and realistic technical objectives to which the program should be directed,
b) defines research projects to attain these objectives,
c) assists in setting research priorities,
d) advises and assists in selecting organizations and personnel to carry out the research project,
e) oversees active projects and advises on the conduct of the research,
f) reviews research reports, including progress and final reports, and assists and advises in evaluating the results of the research, and
g) prepares technical reports and summaries of research work performed under SSC sponsorship and under the surveillance of the SRC.

It has become standard procedure for each organization represented on the SSC to prepare a memorandum report each year on current research needs and suggestions for research projects. Copies of these memorandum reports are transmitted to the SRC. In October, 1976, this procedure was enhanced by holding a joint meeting of members of the SRC, the Hull Structure Committee of the Society of Naval Architects and Marine Engineers, and the Ship Structure Subcommittee to review the reports. The papers were made available in advance of the meeting so that attendees could prepare questions. In addition, the member agencies also presented status reports on the pertinent structural research work under way in their respective agencies.

The suggestions in these reports, those generated within the SRC and its Advisory Groups, and those obtained from other sources are carefully studied for applicability to the SSC research program in terms of need, immediacy, program continuity, and likelihood of successful and meaningful completion. A prospectus is drafted by the appropriate SRC Advisory Group for each of the research projects that is worthy of SSC support and included in an annual report to the SSC. The SSC determines which projects will be supported. When the total scope of the work has been decided, the Naval Ship Engineering Center (NAVSEC) Technical Contract Administrator asks the U.S. Coast Guard (USCG) Contracting Office to prepare a Request for Quotation (RFQ). The prospectus then becomes a part of a Request for Proposal and subsequently a part of the contract document. The RFQ's go to private research laboratories, universities, shipyards, and other organizations and are advertised in the Department of Commerce Daily.

An organization that is interested in doing the work submits a proposal and an estimated cost. The USCG Contracting Office removes the cost data and transmits the technical data in the proposal to the Academy for technical evaluation and review, with the admonition that no information contained in the proposal or the identity of the offerors be made available to the public or to anyone within the Government prior to the Coast Guard making the award. Only those Committee or Advisory Group members participating in the specific evaluation receive the technical data.

The Executive Secretary of the SRC checks each proposal for the names of any committee or advisory group members or their affiliations. He then consults with the Chairman of the SRC to select an ad hoc committee to evaluate the proposals. Any committee or advisory group member with a vested interest in the proposal is excluded from the ad hoc evaluation committee. *This important step avoids conflict of interest.* The evaluation committee generally consists of the Chairmen of the SRC and the pertinent advisory group, two or three other members from either the advisory group or the SRC, the Secretary of the SSC, the Contract Officer's representative, and frequently one or two SSC liaison members. *No one with a vested interest is included.*

The evaluation committee judges the technical merit of the proposals, ranks them, and comments on any shortcomings. When this has been accomplished the results of the technical evaluation are sent to the USCG Contracting Officer.

Upon receipt of the technical evaluation, the USCG Contracting Officer reinserts the cost data and forwards the technical evaluation and cost data to the SSC via the NAVSEC Technical Contract Administrator.

The SSC considers the proposals together with the technical evaluation and costs, and sends its recommendations to the Contracting Officer concerning the organisations capable of doing the work within the funds available, who, following routine procurement practices, then awards a contract.

SRC-SSC research activities during the current year are covered in the annual report by status and progress reports on active and pending projects and synoptic reports on research projects that have been or probably will be completed during the current year. The annual report also includes recommendations to the SSC for research to be funded and started during the ensuing fiscal year. To assist in preparation of next year's annual report, the SSC has placed individual subscriptions to the Maritime Research Information Service (MRIS) in the name of each SRC member and the Advisory Group members for the December 1976 and June 1977 MRIS Abstracts and the MRIS Cumulative Index 1970-1976.

This, the latest in the series of annual reports, covers research activities during Fiscal Year 1977 and sets forth recommendations for the SSC's Fiscal Year 1978 Research Program. This year, as in certain other previous years, the report also outlines a five-year research planning program, which the SRC hereby recommends for SSC consideration. As this report is directed to a very small readership, who are generally in close contact with the evolving programs, no attempt has been made to show how the planned projects relate to the projects done in the formative years of the SSC. However, there are two historical documents that are recommended to serve this purpose. They are:

Twenty Years of Research Under the Ship Structure Committee by S. R. Heller, Jr., A. R. Lytle, R. Nielson, Jr., and J. Vasta, 1967, SSC-182, NTIS AD 663677, and

Third Decade of Research Under the Ship Structure Committee by E. A. Chazal, J. E. Goldberg, J. J. Nachtsheim, R. W. Rumke, and A. B. Stavovy, 1976, SSC-252, NTIS AD-A021290.

The five-year research planning program builds upon current activities, placing them in perspective with contemplated work in various project areas during the next four years. The project areas have been classified under goals which, as far as possible, are designated by headings consistent with those used by the SSC in establishing its research goals. Where additional wording is introduced to designate the goal, this is done to clarify part of the research program.

As presented, the five-year program is to be regarded as flexible. It is intended that the program be dynamic in that it can be modified and redirected to be responsive to changing circumstances.

Part of this program emphasizes research in the general categories of loads, responses, and design methods. In the loads category, work is planned in the specific area of propeller-induced vibration, and work will be continued on slam investigations and tank sloshing. Work will be intensified in the increasingly important area of collision and stranding. In the response area, the need for continued development of prediction methods for rigid-body motions was recognized. Particular emphasis is needed on large-amplitude rolling, following-sea conditions, and unconventional hull forms. In the area of design, probabilistic design and prediction methodology will be studied and applied to structural design.

Propeller-induced vibration will receive greater attention in the coming years. The trend toward increased power for single-screw vessels is expected to continue, even with the increased cost of fuel. Minimizing propeller-induced vibration is still an important objective for present vessel power levels, as well as for the expected higher powered vessels of the future. The complexity of the propeller-hull interaction is recognized and study projects to examine and evaluate methods of wake-field prediction are proposed. A related research project to examine and evaluate methods for predicting the magnitude and nature of propeller cavitation is also being proposed, since it is understood that propeller-induced vibrations are aggravated by the presence of cavitation. To establish a basis for research objectives, a study to evaluate vibration-limit criteria and to propose new criteria as apprcpriate is being proposed.

Opportunities for correlation of analytical and experimental research with full-scale trial measurements in the general area of propeller-induced vibration will be explored. The current program of LNG vessel construction in the United States and abroad may offer such an opportunity.

The program of investigations into collision and stranding research was started during the current year with the funding of a project to evaluate low-energy collision damage theories and design methods. A project will be started to maintain awareness of , and to coordinate ship collision and stranding research studies to provide a basis for further research. It is expected that this project will be a guide to investigators and will help to avoid duplication of effort.

Towing tank model tests, to measure pressures along a ship hull under way, are planned for the coming year. Measurements will be

made for a range of sea conditions, headings, and speeds. The program will be related to past work in part by the use of an SL-7 model as one of the hulls tested. The SL-7 Model-Analytical-Prototype Research Program, which has been funded since 1972, continues primarily in the analysis and correlation phase. A correlation study to relate computer predictions and model tests of ship motion and load data is nearly complete. A similar study is being done to compare stress calculations with full-scale measurements. Collection of extreme stress data continues into the fourth year of a five-year program.

The long-range program proposes research studies on the safety and reliability of ship structures. A probabilistic approach to safety and reliability analysis will be used, recognizing the trade-off between economic limitations and probability of failure. Work in progress on the assessment of uncertainties in analysis and load prediction will be continued. In addition, probability-based criteria will be formulated for design of ship structures against specific modes of failure. Other studies include reliability analysis for fatigue-resistant design and reliability analysis of past structural failures of ships.

Among the prominent parameters that govern the safety and reliability of ships under normal operating conditions are the initiation of fatigue cracks and their propagation to critical dimensions. Fatigue-crack initiation and propagation occur in regions of stress concentration. Thus, the development of a procedure for the selection of ship details based on the fatigue behavior is included in the five-year plan. This work will include the effects of variable amplitude loading similar to those experienced by ships on the high seas, and the effects of sea-water on the fatigue behavior of ship details. The results of this study will be combined with materials toughness

criteria to develop a fracture-control plan for use by ship engineers in the selection of material and geometries of ship details that ensure the safety and reliability of ships.

Work in the important area of weldment quality and economy has been expanded to include an investigation of methods to improve the toughness of the heat-affected zone, especially with high-heat input processes. Study of lamellar tearing and allowable shear stress on fillet welds will be continued. Research will be started to evaluate new and improved plate materials for minimum toughness degradation in heat-affected zones, especially with high-heat input processes.

Weld-quality standards will be studied to furnish guidelines for defect size limits in weldments, heavy section castings and forgings. This work should establish rational limits on defect sizes for ship-steel weldments. Fracture tests will be conducted on weldments containing worst-case weld defects that are within the proposed size limits. Instrumentation for these proposed limits will require development of improved methods to make permanent records from ultrasonic inspections.

Surveys of available operating ship histories, and design and fabrication procedures for aluminum alloys and reinforced concrete will be started. These surveys should identify areas where further research is needed. Follow-up programs will be undertaken on data generation, distortion control, and weld quality standards.

FIG. 1 is a flow chart showing how the Ship Structure Committee's objective will be accomplished through achieving the various goals as detailed in TABLE I. A five-year plan has been

developed for each of the stated and implied contributing technical goals:

Existing and Advanced Concepts
Loads Criteria
Understanding of Response
Materials Criteria
Fabrication Including Inspection/Maintainability
Determination of Success/Failures Criteria (Reliability)
Design Methods

Each of these areas will include adequate verification procedures to assure that sound recommendations are made. In addition, through wide distribution of SSC reports and initiation of an effective universities research program, the marine community benefit goals of information dissemination and education will be met. The thrust will be to expand, as necessary, the existing base of knowledge in each area, to result in design or fabrication procedures that will produce safer and more efficient ships. TABLE II represents the five-year plan in each area.

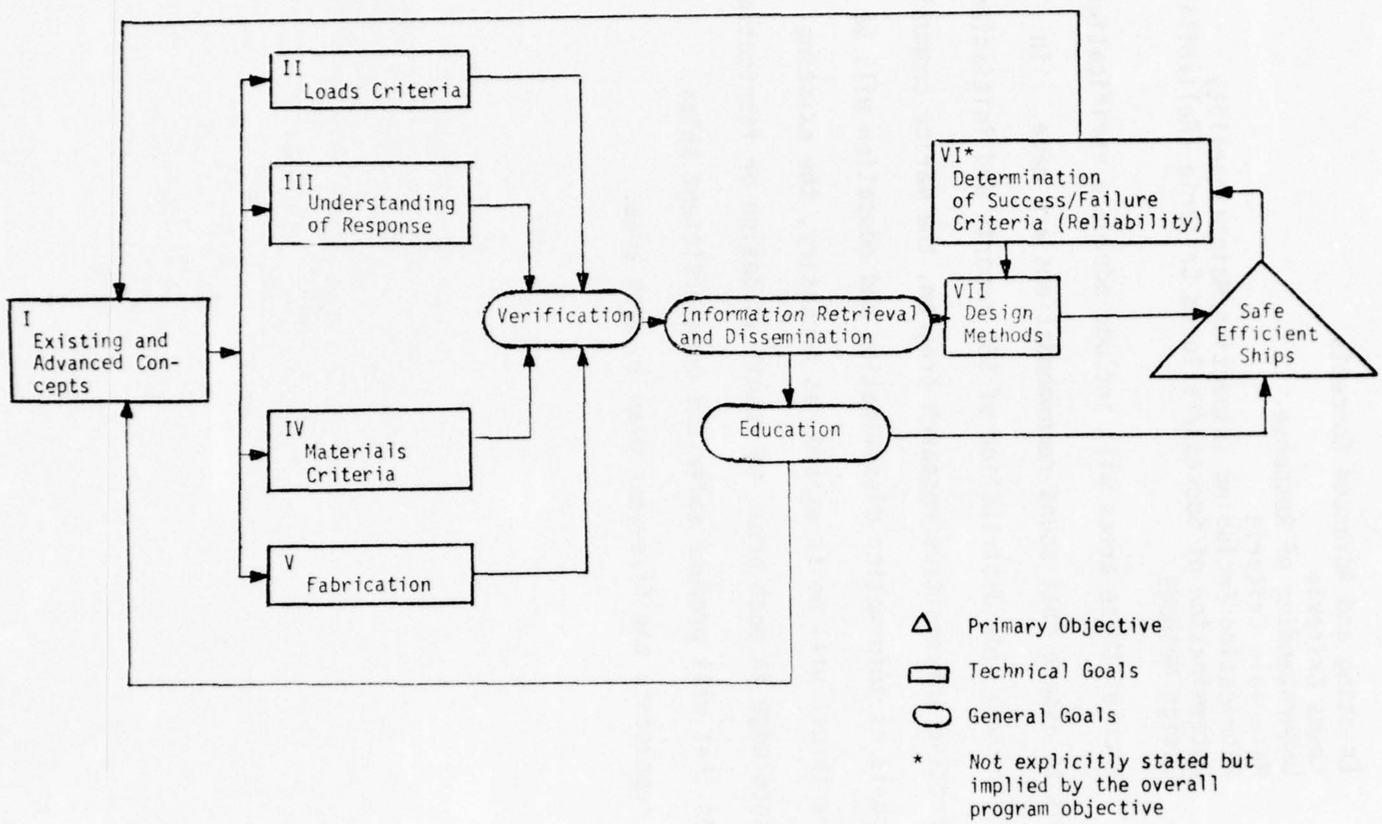


FIG. 1. FLOW DIAGRAM FOR SHIP STRUCTURE COMMITTEE'S COALS TO ACCOMPLISH ITS PRIMARY OBJECTIVE

TABLE I

SHIP STRUCTURE COMMITTEE OBJECTIVE AND GOALS

OBJECTIVE: The objective of the Ship Structure Committee research and development program is to provide information that will assist the U.S. shipbuilding industry in designing and building safer, more cost effective, and more easily maintained Ship Structures by exploiting existing and potential competitive advantage through the advancement of technology.

GOALS: This objective will be accomplished through work leading to achievement of the following goals:

LOAD CRITERIA: Develop improved load criteria, with greater confidence in the severity of loads and the frequency of occurrence. Expand load criteria to include other than quasi-static wave loads.

VERIFICATION: Verify design and analysis theories through simultaneous, coordinated full-scale testing, model testing and theoretical analysis.

DESIGN METHODS: Develop improved design/analysis methods, both in the improvement of the usefulness of existing design/analysis theories and in the development of new theories and techniques. Interpret results of R&D so that this can be presented in a form suitable for use in the design office.

ADVANCED CONCEPTS: Identify structural problems of advanced ship design concepts and address solutions to these problems.

MATERIALS CRITERIA: Develop improved criteria for the application of shipbuilding materials systems (base materials, fabrication materials and techniques, and testing). Investigate improved structural materials to meet this criteria. Establish methods for direct synthesis of material property requirements in the design process.

FABRICATION: Develop improved techniques and guidance for ship erection and construction including improved test techniques.

INFORMATION RETRIEVAL AND DISSEMINATION: Identify ship structure problems, and improve information retrieval and dissemination of the results of research to those concerned with modern ship hull structural problems. (This can be achieved through increased coordination with technical societies, committees, etc. It is envisioned that the SSC could serve as a vehicle for coordination of all ship structural research in the United States. The possibility and advisability of participation in a foreign information exchange program should be investigated.)

EDUCATION: Promote the teaching of structural naval architecture in the United States.

TABLE II

SHIP RESEARCH COMMITTEE'S RECOMMENDATIONS FOR FIVE-YEAR RESEARCH PLANNING PROGRAM FOR THE SHIP STRUCTURE COMMITTEE

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL: I - EXISTING AND ADVANCED CONCEPTS			
Structural problems of advanced ship design concepts	Conduct joint meeting to develop Agencies' and Societies' present and planned research work. Initiate project to determine feasibility of obtaining casualty data and a plan to analyze data.	Examine current marine structural research status (all agencies). Develop an overall outline to accomplish general objectives.	Initiate project to develop coordinated plan including specific proposed technical approaches for each section. Provide detailed references to past and existing work both domestic and foreign. Provide cost estimates and a cost-benefit ratio.	Conduct workshops to gain additional input and priorities to the coordinated plan.	Commence following research plan.
	Determine feasibility of using existing data banks to analyze ship damage for developing a method to determine research priorities. (SR-247)	Critically analyze ship structural casualty data to determine relative costs of existing deficiencies.			
		GOAL: II - LOADS CRITERIA			
Static/Quasi Static Thermal (Diurnal, Cryogenic, Hot) Cargo, Ballast, Fuel, Cargo Distribution, Light Weight of Ship, Ships Induced Wave, Ice, Impact, Crushing.	SR-227 compiled and analyzed several loading variables for three different types of ships.	Complete SR-227.			

TABLE II

GOAL: II - LOADS CRITERIA (Cont.)

PROJECT AREA	1977	1978	1979	1980	1981
Static/Quasi Static (Cont.)		Initiate program to obtain static/quasi static data for typical ships.	Complete data collection program.	Prepare Design Load Profiles. Recommend modifications to Design Criteria.	
					Review MARAD's and USCG's data collected on Great Lakes and Icebreakers to establish any distinctive problems of loading and to propose design criteria.
Dynamic Cargo Liquid, Sloshing, Dry, Shifting Load, Pumping Problems, Mobile Cargo (Wheeled Vehicles)	SR-251 is to survey, test, analyze, and develop liquid dynamic load criteria in slack cargo tanks for LNG carriers.	Review and correlate current model and full-scale liqud slosh data. Conduct model tests to complete correlations for various fill depth, geometry, and excitation parameters.	Develop general purpose curves and tables for use in design of liquid cargo tanks.	Conduct analyses and/or tests to establish dynamic loads and corresponding structural responses to shifting cargo under typical operational conditions.	Develop curves and tables for ready use in design for dynamic loads due to shifting cargo.
		Evaluate significance of impulsive slosh loads in full-scale liquid tanks. Develop prediction of wall response to impulsive slosh pressure. Recommend design criteria for tank walls.	Review and categorize types of shifting cargo loads, and establish priority of dynamic load problems. Develop plan for analysis of high-priority items.		

TABLE II (CONT.)

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL: II - LOADS CRITERIA (CONT.)			
Propeller-Induced	Begin survey and evaluate present methods to predict propeller-induced vibration in hull structural elements, including skewed propellers. (SR-240).	Complete SR-240.			
			Identify and describe existing analytical methods for predicting wake fields.	Develop correlation of wake-field studies.	Evaluate correlation studies and produce wake-field guide.
			Identify and describe analytical methods for predicting magnitude and nature of propeller cavitation.	Develop program, and conduct tests to validate cavitation study results.	Evaluate cavitation studies and produce guide.
			Consider effects from propeller emergence.	Develop test plan to measure propeller emergence effects.	Initiate test plan to measure propeller emergence effects.
Wave-Induced Wave Records/Spectra Local Ship Wave Instrumentation Slamming, Green Water, Steady State	Complete full-scale slam instrumentation package. (SR-235).	Develop prospectus for full-scale slam instrumentation and wavemeter data collection.	Collect full-scale trial slamming and bow-flare impact data using the instrumentation developed under Project SR-235.	Analysis of impact pressure and velocity. Correlate trials data with model experiments and theory.	Develop technology to predict impact loads for ship design consideration.
		Complete SR-221 correlation and verification of wavemeter data from SL-7.	Collect and analyze wave information at locations of interest along trade routes by using reliable wave recorder.	Continue collection and analysis of wave information and develop long-term wave statistics necessary for fatigue failure analysis.	Develop a method to statistically estimate the combined wave-induced bending and torsional loads necessary to perform structural failure analysis.

TABLE II (CONT.)

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL: II - LOADS CRITERIA (CONT.)			
Collision and Stranding and Dry-Docking Loads.		Develop dry-docking and low-energy stranding loads, and analysis program.	Consider adding wave loads on stranded ships.	Establish the common technologies applicable to both ship collision and stranding problems.	
	Evaluate existing low-energy collision damage theories and possible use and limitations. (SR-237)	Review SR-237 results and prepare prospectus for 1979 work.	Develop computer simulations of low-energy ship collision dynamics for various collision scenarios.	Develop and perform full-scale or model tests to verify computer simulations and to establish important collision phenomena.	Complete test program.
	Monitor collision and stranding research and issue status reports.	Continue surveillance of ship collision/stranding research studies.	Continue surveillance of ship collision/stranding research studies.		
		GOAL: III - UNDERSTANDING OF RESPONSE			
Vibrations Analysis & Prediction Steady State (Springing, Bending, Torsion). Transient, (Whipping), Acoustic Transmission Measurement/Verification.		Collect and evaluate ship structural damping data to extend design.	Indicate test program to verify design extensions.		

TABLE II (CONT.)

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL: III - UNDERSTANDING OF RESPONSE			
Vibrations (Cont.)			Begin analysis and measurement on different ship propulsion shafting systems in order to prepare a set of guidelines for the analysis of thrust-bearing foundation stiffness. (Research Project M-8 from SNAME Panel M-20).	Complete analysis and preparation of Thrust-Bearing Foundation-Stiffness Guide.	
Stress/Deformation Analysis & Prediction Measurement/Verification, Steady State, Transient, Static, Thermal	Verification of calculated stress as compared to full-scale measured values. (SR-236). Initiate pressure distribution model tests in waves to determine necessary strength of local structure (SR-252).	Continue stress verification program. Continue pressure distribution model tests. Use Webb computer program to calculate pressure distribution corresponding to model tests.	Compare model and computer results for pressure distribution.		
	Continue collection and reduction of SL-7 scratch-gage data (SR-215 and SR-245).	Review scratch gage data and make recommendation to either continue SL-7 data collection or use different type of ship.	Scratch-gage extreme stress data collection. Include areas suspected of low stress for confirmation and possible scantling reductions.	Scratch-gage extreme stress data collection.	Scratch-gage extreme stress data collection.
Motions (Rigid Body) Analysis/Prediction Measurement/Verification motions in Following Seas, Non-conventional Forms, Multi-hull, Hydrofoils, Submersibles.		Prediction of the behavior of advanced marine vehicles (non-conventional types) in a seaway.		Prediction of non-linear roll response and roll stabilization in irregular seas. Initiate project to complete comparisons of load computer programs with full-scale data remaining after SR-236 and SR-252.	Modify seakeeping ship loading programs to include non-linear roll response.

TABLE II

GOAL: IV - MATERIALS CRITERIA

PROJECT AREA	1977	1978	1979	1980	1981
Materials Trade-Off	Examine potential of different materials for advance ship types, unique operation, and special capabilities. (SR-222).	Review results of SR-222 and establish future direction.			
Concrete			Conduct a brief survey on available operating histories of reinforced concrete. Develop a test and research program to provide safety equivalence in reinforced concrete to steel.	Conduct test and research program on reinforced concrete for ship application.	Complete test program, formulate recommended design criteria for a broad range of reinforced concrete ships and marine structures. Determine design procedures that have resulted in satisfactory performance. Identify areas where performance histories are not available.
Aluminum			Survey of applications, properties of aluminum alloys and weldments, review shipyard fabrication procedures and service experience, identify problem areas.	Follow up program on data generations, distortion control, weld quality standards, etc., as identified in the 1979 program.	Design/Fabrication Guideline development.
Composites					Review status and applicability of composites.

TABLE II

GOAL: IV - MATERIALS CRITERIA

PROJECT AREA	1977	1978	1979	1980	1981
Fracture Toughness	Characterize the nil ductility temperature (NDT) and dynamic tear (DT) energies of ship steels. (SR-224). Delineate the loading rate effects on fracture initiation. (SR-231).	Review fracture arrest studies in thick-walled vessels under plane-strain conditions as funded by U.S. Nuclear Regulatory Commission and the Electric Power Research Institutes.	Participate in fracture-arrest studies for ship steels.	Make an assessment of the fracture criteria developed in terms of NDT and DT test results in light of the SR-224 and SR-231 results.	See Goal VI.
Fracture and Fatigue Control	Initiate studies to determine relevance of Charpy V-notch energy criteria on assessing steel weldments containing fatigue cracks. (SR-238).	Identify fatigue and fracture-controlled details in ship structures. Evaluate available procedures for evaluation and selection of fabricated structural details under cyclic-loading conditions. Classify the behavior and severity of ship details under cyclic loading using the best available procedure.	Conduct experimental work to verify the classification procedure selected in the previous work. Conduct experimental work to classify the behavior and severity of the details whose behavior is not known.	Utilize the preceding work and other available information to develop a viable fatigue criteria and design procedure for the selection of ship details under variable amplitude loading conditions representative of actual operating conditions for ships.	
			Initiate a study of internal and external environmental effects on ship steels.	Conduct limited experimental programs of internal and external environmental effects on ship steels.	Identify modifications, if necessary, to the selected fatigue criteria to account for environmental effects.

TABLE II (CONT.)

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL: V - FABRICATION TECHNIQUES			
Improved Weld Quality Guides	Survey existing nondestructive inspection (NDI) methods to adapt to underwater use. (SR-243). Survey and evaluate secondary structural welds such as for webs and longitudinals to determine if additional inspection guidelines are needed. (SR-249).	Review the nondestructive inspection practices used for heavy section castings, forgings and weldments and prepare an interpretive report of the procedures and acceptance limits applicable to ship components.	Establish the significance of present allowable defect sizes on the safety and reliability of ship details using various available procedures including fracture mechanics analysis. Recommend program to develop improved standards for allowable defect sizes using currently available service experience.	Verify that the proposed limits on defect sizes for ship steel weldments provide adequate safety. Conduct fatigue and fracture tests on weldments containing worst-case weld defects that are within the proposed size limits. Characterize initial defects by both ultrasonic and radiographic inspection methods. Develop improved methods for obtaining and analyzing permanent records for ultrasonic inspection.	Provide guidelines for the implementation of the proposed defect-size limits into ship construction practice. This implementation may require the use of the developed hard-copy records for ultrasonic inspections.
Structural Details	To examine different sound and failed structural details in selected ships to evaluate their analyses. (SR-232).	To continue the survey on thirty-six additional ships to establish probability data.	To review and combine previous project results into a design and fabrication manual.		
	Initiate study to update the allowable shear stress on fillet weld requirements. (SR-248).	Complete update on allowable shear stress in fillet welds and determine if research work is needed.	Undertake such additional fillet weld testing as required.	Provide recommendations for allowable shear stress in fillet welds.	
	Prepare design guidelines, welding procedures and testing methods to prevent lamellar tearing in ship steels. (SR-250).				

TABLE II

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL: V - FABRICATION TECHNIQUES (CONT.)			
Effects of High-Deposition Weld Rate	Survey MARAD's program evaluating high-deposition rate processes (ES & EG) and their effect on weldment properties.	Initiate a study to evaluate new improved plate materials for minimum HAZ property degradation, especially with high-heat input processes.	Evaluate behavior of new plate materials in high-deposition rate welding processes. Continue evaluation of ES and EG high-deposition rate processes. Use data developed in SR-238 to evaluate weldment properties. Initiate program to evaluate effect of other high-deposition rate weld processes on weldment properties.	Determine if new materials and/or processes provide adequate service life using fracture and fatigue control plan tests.	Provide an initial guide for use on high-deposition rate weld processes in ship construction.
		GOAL: VI - DETERMINATION OF SUCCESS/FAILURE CRITERIA (RELIABILITY)			
Fatigue/Fracture		Develop reliability analysis and criteria for fatigue-resistant design of ship components.	Review safety analysis of ship structural details against fracture failure, and develop reliability-based inspection and maintenance schedules to insure safety against brittle fracture.	Review fracture-control plans used for structures other than ships to determine their applicability to ships.	Develop a fracture-control plan for ship structures that incorporates both fatigue and fracture behavior of fabricated ship details.
Buckling/Excessive Deformation/ Plastic (Permanent Set)	Develop an analysis method for uncertainties associated with ship hull strength and develop expressions for margins of safety and structural reliability. (SR-241).	Formulation of risk-related or probability-based criteria for design of ship hulls against specific modes of failure; this may include (a) ships of conventional (steel) material; (b) ships of reinforced and/or prestressed concrete; (c) ships of future marine material, e.g., composites.	Undertake reliability based analysis of past structural failures of ships.	Develop post-damage serviceability evaluations of ship hull structures.	

TABLE II (CONT.)

PROJECT AREA	1977	1978	1979	1980	1981
		GOAL VII - DESIGN METHODS			
Design Procedures Efficiency, Economics/ Optimization, Test and Evaluation, Preliminary Design.	Evaluate effect of varying ship proportions and hull materials on hull flexibility. (SR-239)	Review SR-239 results.	Establish deflection criteria for ship in relation to main machinery alignment tolerances. Fabricate and test large-scale models of hull elements to verify criteria.		
		Develop procedure for determining ultimate strength under combined vertical, lateral, torsional loads.	Fabricate large-scale hull girder model and test to failure, measuring stresses and deformations and comparing with calculations.	Evaluate possibility of using ultimate strength in hull girder design rules.	
			Review existing optimization techniques and develop a computer program for preliminary design.	Verify the preliminary design program.	
				Develop preliminary design paramoters for ends of ship to avoid vibration and slamming damage.	Study methods and structures to reduce damaging effects of ship collisions using verified computer simulator programs with large-scale ship collision tests.
					Extend design procedure for suddenly applied loads; shock, explosion and thermal shock/

NOTES

FISCAL 1978 PROJECT RECOMMENDATIONS

Table III lists the projects proposed for the 1978 Fiscal Year in priority order. Prospectuses for these projects are presented in the same order. Some of the prospectuses may seem specific and detailed, whereas others appear to be general. This is purposely so, reflecting the judgment of the SRC that potential contractors should be constrained on certain projects and encouraged to propose their own approaches or methods for others.

As in past years, more projects are included than are likely to be funded with the anticipated support. However, the possibility of greater support, the need of the SSC for a reasonable number of projects from which to select, and the possibility that some projects not initiated in Fiscal Year 1978 could well be included in the program for the following year, suggest that the preparation of the additional prospectuses is a useful service.

TABLE III - RECOMMENDED PROJECTS FOR THE 1978 FISCAL YEAR

DEVELOPMENT OF SHIP STEELS WITH IMPROVED WELDABILITY SRC Priority 1

Long-Range Goal: Materials Criteria, Fabrication

BACKGROUND

Much of the modernization taking place in the world shipbuilding industry in the last decade has centered around the use of new, more efficient welding techniques. This is not particularly surprising since it has been estimated that 30 to 50% of the total man-hours in hull construction is associated with the welding portion of the fabrication [1,2]. The potential increase in productivity with new high-deposition rate welding processes is considerable. The Japanese are making significant strides in the use of multihead submerged-arc, CO_2/A-shielded GMAW and electro-slag/gas processes[3-5].

Domestically, experimental work on electro-slag/gas welding for marine applications has been initiated under the Bethlehem-MARAD program [6]. This study has identified the need for an improved ship hull steel which would exhibit minimum tendencies for heat-affected-zone (HAZ) and weld-metal property degradation. Work is proceeding in this direction with the current MARAD-NBS ship steel improvement program. Weldments in low sulfur and sulfide shape-controlled plate steels are being evaluated using higher deposition rate welding practices. However, in order to take full advantage of the benefits of the new welding practices, additional metallurgical control appears necessary for minimizing HAZ and weld-metal property degradation.

WORK SCOPE

The contractor should first conduct a literature survey to determine the state of the art in shipbuilding as well as in related industries. New processes, plate materials, and the ship structure

areas where they are used should be identified. Specific comparison to current U.S. shipbuilding techniques in identical areas is recommended. Work should be directed toward determining the weld procedure and metallurgical control necessary to develop adequate toughness in the weldment, using high-deposition rate processes.

This program should be accomplished within three years. Estimated objectives and man-hour requirements are given below.

PHASE I

Survey the literature, develop potential metallurgical controls and start developing improved ship steels for high deposition rate welding.

PHASE II

Evaluate HAZ and weld metal behavior of the improved steels in a variety of high deposition rate welding processes and procedures.

PHASE III

Continue detailed evaluation and select the optimum (including costs) materials, processes, and weld treatments to provide adequate service life, using the proposed fracture and fatigue control plan tests.

MAN-HOURS

Phase I	-	2000
Phase II	-	2000
Phase III	-	3000

REFERENCES (For Background Use Only, Need Not Appear in Request for Proposal)

1) Naval Intelligence Command (NIC) Translation No. 2881 of 8/29/69, "Improving the Building of Ship Hulls;" Russian Shipbuilding No. 11, 1962.

2) Structural Design and Fabrication in Shipbuilding Conference, Paper 8, "Recent Development of an Automatic Welding System Applied to the Japanese Shipbuilding Industry", Int. Conf., London, Nov. 18-20, 1975, The Welding Institute, Abington Hall, 1976.

3) Ibid, Paper 13, "Improvement in Welding Technology at the Tsurumi Shipyard".

4) Ibid, Paper 22, "High Productivity One-Sided MIG-Welding Technique".

5) Ibid, Paper 23, "The One-Sided Submerged-Arc Deep Penetration Welding Process with Lower Heat Input".

6) Bethlehem Project Report to U.S. Maritime Administration, "Toughness Evaluation of Electrogas and Electroslag Weldments", March 1975.

LIQUID-SLOSH LOADING IN CARGO TANKS SRC Priority 2

Long-Range Goal: Load Criteria, Verification

BACKGROUND

Dynamic loads of various types of liquid cargo must be considered carefully in the design of ship structures. Low frequency slosh pressures in nearly filled tanks, as well as rapid impact pressures due to shifting under slack conditions give rise to a range of design problems. Heretofore, these problems have been approached on an individual ship application basis, and most of the available information is scattered in various technical journals. Furthermore, problems associated with slosh of certain liquids have been studied more intensively than others. In particular, loading in LNG carriers has received most detailed attention in recent years. For example, SSC-258, A Study to Obtain Verification of Liquid Natural Gas (LNG) Tank Loading Criteria, dealt with a preliminary verification of LNG tank loading criteria, as well as other fluid loads, by means of evaluating certain existing data. More recently SSC project SR-251, "Evaluation of Liquid Dynamic Loads in Slosh Cargo Tanks", includes objectives to review all available literature for data, to attempt to correlate the data on a common basis, and to perform experiments to fill in gaps where necessary. However, emphasis is placed on the LNG slosh problem. Other liquid cargoes present different dynamic loading problems because of differences in liquid properties, tank geometries, and design considerations. Thus, a similar program to study loads associated with other general types of liquid cargo is required.

WORK SCOPE

A two-year program should be undertaken to survey and correlate all available data on dynamic loads in liquid cargo tanks. All currently practical types of liquid cargoes, tank designs, and liquid fill conditions should be included. Experiments should be conducted to fill in information gaps where necessary. All data should be combined into a useful design guide.

SPECIFICATIONS AND SPECIAL PROVISIONS

PHASE I - Parameter Study

The contractor shall compile and review all existing analytical, model, and full-scale data for prediction of slosh loads under various operating cargo conditions. Emphasis shall be on liquid cargoes other than LNG. Both U.S. and foreign sources of information shall be investigated. Data and predicted values from analyses shall be correlated according to suitable non-dimensional parameters, and may be grouped according to particular applications. Additional scale-model experiments shall be conducted to obtain supplementary data for filling information gaps, where necessary. These data shall be combined with the LNG data compiled under SR-251.

A formal technical report shall be prepared covering Phase I.

PHASE II - Liquid Impact Study

A special study shall be conducted to determine the significance of impulsive slosh loads in slack cargo tanks. Analyses and/or tests shall be performed to provide prediction of typical full-scale wall responses to impulsive pressure.

PHASE III - Design Guide Preparation

The contractor shall compile all information acquired under

Phases I and II into a general guide for use in the design of liquid cargo tanks. Data may be presented in a catalog of liquid cargo types and/or nondimensional parameters selected for most convenient use. Consideration of tank geometries, liquid properties, ship motions, typical tank design, and other parameters should be included.

A formal technical report shall be prepared to cover Phase III.

MAN-HOURS

Phase I - 3000

Phase II - 2500

Phase III - 1500

SURVEILLANCE OF SHIP COLLISION/STRANDING RESEARCH STUDIES SRC Priority 3

Long-Range Goal: Information Retrieval and Dissemination

BACKGROUND

The Ship Structure Committee received a long-range collision/stranding research plan, Fig. 1, in its fiscal 1977 research program recommendation. An early task in this plan will be Project SR-246, to identify and monitor all past and current research relevant to ship collision/stranding. The results will serve to keep the SSC, SRC, and all other interested parties aware of past, ongoing, and planned research projects in the area.

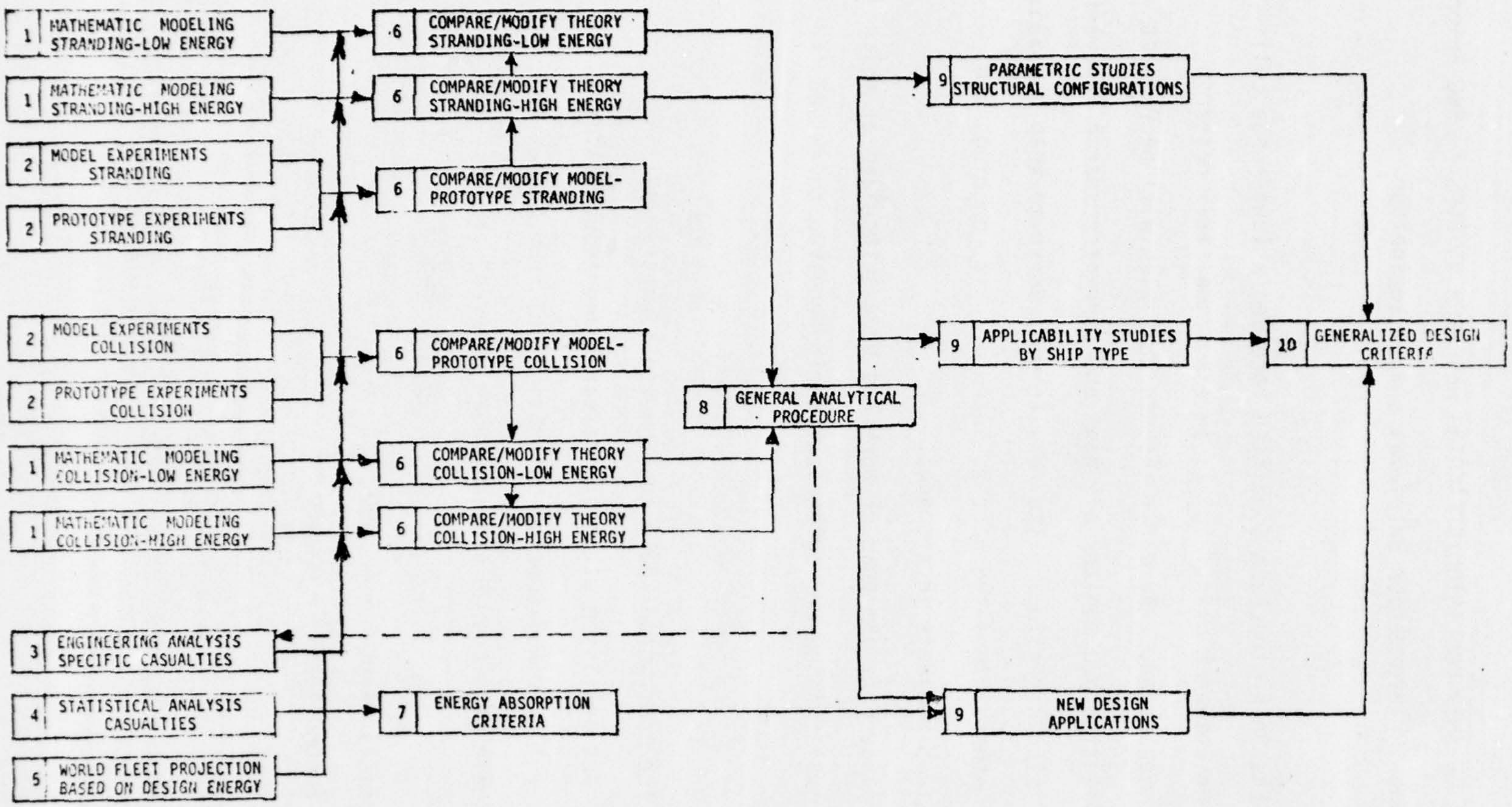
Since only one year of work had been authorized at this time, additional funding and authorization is required to extend the work.

WORK SCOPE

The contractor shall continue to identify and monitor past and current collision/stranding research and issue status reports that will include concise discussions of new reports or programs on related research projects both here and abroad.

MAN-HOURS

First Year	-	500
Second Year	-	500



THE NUMBER IN EACH BOX REFERS TO CONDENSED PROJECT DESCRIPTIONS PROVIDED ON THE FOLLOWING PAGE

FIG. 1 -FLOW DIAGRAM FOR LONG-RANGE COLLISION/STRANDING RESEARCH PLAN

DESCRIPTION OF ITEMS SHOWN IN FLOW DIAGRAM FOR LONG-RANGE COLLISION/STRANDING RESEARCH PLAN

1. Mathematical modeling of Collision or Stranding involving high energy (rupture of shell) or low energy (shell deforms but remains intact). Projects to include application of loads, rigid body mechanics, hydrodynamic response including added mass and hull static and dynamic response (deflections, vibration, fracture), structural framing systems, materials (steel, concrete, aluminum, and hybrid combinations), absolute and relative motions of impacting vessels (cr grounding surfaces), typical grounding surfaces.

2. Model and Prototype experiments for high and low energy collisions or strandings. Testing parameters for prototype and model testing to include critical examination of effects of scaling, model fabrication techniques, model materials, entrained water, relative motions, time durations, ideal versus available testing facilities, and environmental considerations when testing in prototype scale.

3. Engineering Analysis of Representative Casualties involving high and low energy collisions and strandings with particular emphasis on compiling data needed to analyze the mechanics of the structural response and failure.

4. Statistical Analysis of Collision and Stranding Casualties - Worldwide statistical survey to provide estimates of risk of collision and stranding based on service, route, season, and such other factors that are deemed appropriate.

5. World Fleet Projections Based on probable Collision Energy (Displacement Tonnage and Design Speed) and Bow Configurations.

6. Compare and Modify Theory or Experiments for Collision or Stranding (High and Low energy). Evaluate errors in each, estimate validity, and suggest changes to improve either theory or experimental techniques.

7. Data Analysis for Energy Absorption Criteria - Develop energy absorption criteria for various ship types so that the ship can expect to have the critical barrier remain intact in — % of the expected collisions/groundings.

8. General Analytic Procedure based on Theoretical Studies as modified by Experimental Studies.

9. Specific Design Studies incorporating various structural configurations, differences based on ship types, and new design applications such as frangible bows, protective barriers, etc.

10. Generalized Design Criteria - combine results from the various prerequisite studies to define design criteria, including consideration of geometry and structural design, for low- and high-energy casualty and stranding protection.

FATIGUE CHARACTERIZATION OF FABRICATED SHIP DETAILS SRC Priority 4

Long-Range Goal: Fabrication, Load Criteria

BACKGROUND

Ships under actual operating conditions are subjected to cyclic loadings that start and propagate fatigue cracks at critical details. These cracks are usually detected and repaired, but occasionally may lead to severe damage and possible loss of life. Consequently, there is a need to evaluate the behavior and useful life of fabricated ship details under cyclic-loading conditions that represent actual operating conditions for ships.

The various details used in the fabrication of ships have been cataloged in an SSC-266 report titled, Review of Ship Structural Details . A survey of damage and repairs to ship details is being conducted under Ship Research Project SR-232, "Structural Details Failure Survey". The information from these projects should be combined with available fatigue-design procedures, such as the American Association of State Highway and Transportation Officials' (AASHTO) fatigue-design procedure for bridge details and the American Society for Mechanical Engineers' fatigue-design procedure for pressure vessels, and the experimental results obtained in this program. The result should be a classification of fabricated ship details in terms of their behavior and useful life under cyclic-loading conditions, using the best available design and selection procedure to ensure the safety and reliability of ship details. The research should also result in specific recommendations for implementing the findings in the design of ships.

LONG-RANGE OBJECTIVES

The long-range objectives are to establish:

a) fatigue design requirements for fabricated ship details,

b) procedures for evaluating and selecting fabricated ship details that are subjected to cyclic loading,

c) recommendations to incorporate this procedure into ship design.

OBJECTIVES

PHASE I

The objectives for Phase I are to:

a) appraise available procedures for evaluating and selecting fabricated structural details under cyclic-loading conditions,

b) classify the fatigue behavior and determine the useful life of ship details under cyclic loading, using the best available procedure.

DESCRIPTION OF WORK

1. Conduct a literature survey.

2. Evaluate available procedures for classifying the behavior and determine the useful life of fabricated structural details under cyclic-loading conditions.

3. Classify fabricated ship details according to their behavior and useful life under cyclic-loading conditions using the procedure most useful to design engineers.

4. Determine those details that need further experimental work to define their behavior and useful life under cyclic-loading conditions.

5. Show how the selected classification procedure can be used by design engineers to ensure the safety and reliability of the selected detail under operating conditions (give details of the steps necessary to accomplish this objective with specific examples).

The selected classification procedure must be easy to understand and to incorporate into the design of ships. It should be presented using simple parameters such as stress range and cycles-to-failure, as was done in the AASHTO fatigue-design procedure.

PHASE II

The objectives for Phase II are to:

a) verify the classification procedure selected in the previous work,

b) classify, according to the selected procedure, the behavior and useful life of fabricated ship details whose behavior is not known.

DESCRIPTION OF WORK

1. Conduct experimental work on selected details from each class of behavior to verify the accuracy of the classification procedure that was selected in Phase I.

2. Conduct experimental work, using the selected procedure, to classify the behavior and useful life of fabricated ship details whose behavior is not known.

MAN-HOURS

First Year	-	2000
Second Year	-	3000

STRUCTURAL DETAILS FAILURES SURVEY CONTINUATION SRC Priority 5

Long-Range Goal: Design, Materials, Fabrication

BACKGROUND

Project SR-216, "Review of Ship Structural Details", provided designers with a catalog of common design details. In Project SR-232, failures of structural details on 50 ships were surveyed to identify the relative effectiveness of the details. Determination was made in Project SR-233, "Structural Tolerance Survey", of expected deviation from "ideal" design. Meanwhile, other projects are being proposed to characterize the fatigue behavior of fabricated ship details. Because this work will require correlation with actual service history and because of the limited level of effort of Project SR-232, it is recommended that Project SR-232 be continued.

WORK SCOPE

Continue the survey to identify the effectiveness of design details, concentrating on the midship/cargo section of the ships and attempting to extend/confirm the conclusions of SR-232 relating to problem detail types and location.

SPECIFICATIONS AND SPECIAL PROVISIONS

The contractor shall continue to survey an additional 12 bulk carriers, 12 general cargo ships, and 12 containerships.

Failures should be cataloged in the same format as that used for Project SR-232. The number of details with problems, should be compared to the total number of the same type surveyed.

MAN-HOURS

1200

NONDESTRUCTIVE INSPECTION OF HEAVY SECTION CASTINGS, FORGINGS, AND WELDMENTS SRC Priority 6

Long-Range Goal: Fabrication

BACKGROUND

With the increased size of ships, there has been an attendant increase in the section size of forgings, castings, and weldments (stern frames, rudder horns, stern tubes, tail shafts, propellers, and some engine parts.) In many cases, persons trained in nondestructive test inspection (NDT) methods applied to ship plating must inspect such large elements without benefit of any guidelines.

WORK SCOPE

The investigator shall survey results of representative NDT methods for ship castings, forgings, and weldments, and attempt to determine the quantitative acceptance standards in use.

SPECIFICATIONS AND SPECIAL PROVISIONS

1. The investigator shall write an interpretive report of the state of the art in this field.

2. The survey should emphasize ship components, but methods and criteria developed for the manufacture of other heavy section castings, forgings, and weldments, should also be considered.

3. Items to be dealt with shall include:

   a) Extent of inspection, based on critical loading and other considerations.

   b) Preparation required for each method prior to conducting inspection.

   c) Major methods considered applicable.

   d) Accept-reject criteria, if different from those ordinary sized items.

e) Illustration of typical current practices involving heavy section castings, forgings, and weldments, by application type.

4. Propose tentative guidelines and recommend future work to lead to improvement in those guidelines.

MAN-HOURS

800

FATIGUE CONSIDERATIONS IN VIEW OF MEASURED LOAD SPECTRA SRC Priority 7

Long-Range Goal: Materials Criteria, Design Methods

BACKGROUND

In recent designs of ships and marine structures, considerable attention has been given to a probabilistic approach to structural dynamics. The aim is to evaluate possible failure of the structure resulting from random excitation (wave loads) in a seaway. Two different types of failure have to be considered: one is the first excursion failure associated with extreme stress; the other is fatigue crack growth associated with the number of occurrences above a certain stress level experienced by the ship in its lifetime.

The 1975 "Recommendations for Needed Structural Research" by the ABS asserts that "crack growth and propagation characteristics observed in ship hulls appear to be appreciably less than that predicted on the basis of fracture mechanics studies based om small-scale specimen tests." The work of Gurney (British Welding Research Association) and of Fisher (Lehigh University) on fatigue of weldments indicates that a) the endurance of weldments is directly predictable from steady-load crack-propagation behavior, and b) the cycles before fatigue initiation in ordinary weldments is a negligible portion of the fatigue life. These results suggest that extraordinary fatigue life in ship service must result from some other cause. The best known of such effects is crack-growth retardation associated with load-spectrum excursions, or overload retardation. This averts fast-fracture initiation in cracks where current fracture-mechanics theory would predict failure.

Spectra-retardation effects are well known and used in aerospace applications. The Wheeler and Willenbourg retardation rules are well known and proven. Calculation of these effects requires knowledge of the load spectra - a subject well researched in the aircraft industry.

Dynamic loading patterns in ships are not well known. However, stress data collected on the containership SL-7, now available in a Teledyne data bank (SR-211) makes it possible to assess load spectra effects on a ship in service.

<u>WORK SCOPE</u>

1. Review the SL-7 and other ship data banks with a view to establishing fatigue loading spectra either as specific history or as a generalized pattern.

2. Compare these data to data and methodology relating to overload retardation of fatigue cracks to determine whether a significant degree of retardation can be attributed to typical sea experience.

3. Attempt to correlate the results with fatigue cracking observed in the SL-7 and other ships.

4. Assess influences, if any, on the margin of safety provided by design tolerances of ABS and or standard bodies.

<u>MAN-HOURS</u>

2400

HULL STRUCTURAL DAMPING DATA SRC Priority 8

Long-Range Goal: Design Methods

BACKGROUND

Increases in ship propulsive power and the advent of low-draft bulk carriers have created numerous instances of unacceptable ship structural vibration. As a result, ship buyers increasingly insist on adding vibration performance criteria to ship's specifications. Such criteria are usually in terms of maximum acceptable accelerations and/or velocities for specific regions of the ship's hull.

Many new ships have been temporarily taken out of service or operated at less than design power to reduce vibration. The operating and capita cost per day of a large tanker or LNG ship ranges from $20,000 to $50,000. It is not difficult to assume world-wide yearly losses of several million dollars. Those losses could largely be avoided by providing the data required for vibration response analysis.

To comply with vibration criteria, shipbuilders must depend on analytical data, the reliability of which may be inadequate to support performance guarantees.

Two troublesome areas in response analysis are the prediction of magnitude and phasing of exciting forces and the structural damping characteristics of the hull.

No systematic evaluation and presentation of damping data are available, yet the variation in commonly used data can result in unacceptable response prediction errors. For predicting the vibratory

response of the hull-girder and local structures, a determination of the total damping coefficient, including hydrodynamic, structural, and cargo damping components is needed. The hydrodynamic damping component may be approximated on the basis of strip theory. However, at the present time, the structural and cargo damping components can only be determined by means of a full-scale experiment. Measurements of damping coefficient with respect to hull-girder and local structure vibration should be carried out on board ship. These data could then be used to estimate damping coefficients for related ships.

WORK SCOPE

The contractor shall collect and evaluate structural damping data applicable to ship vibration analysis, and shall recommend an experimental program, model or full scale, to extend and verify design data.

SPECIFICATIONS AND SPECIAL PROVISIONS

1. The survey shall not be limited to a particular ship type. Data shall be categorized in terms of the essential characteristics of the ship: type of vessel, framing system, draft, location and condition of tanks, weight distribution, etc.

2. Special attention is to be given to spaces occupied by the crew.

3. Proposals for full-scale measurement should consider minimum impact on normal ship operations.

4. Preliminary recommendations should be formulated of damping values for use in design.

MAN-HOURS

800

ULTIMATE STRENGTH OF SHIP HULL GIRDER SRC Priority 9

Long-Range Goal: Design Methods

BACKGROUND

Knowledge of the ultimate strength of ships is important, particularly in determining the appropriate margins of safety or the probable risk of failure under the loads acting on the ship. Some work has been done on determining ultimate strength under vertical bending moment. Further work is necessary to determine the strength under a combination of vertical, lateral, and torsional loads. This investigation should include analytical prediction of elastic buckling, yielding, plastic buckling, and collapse under a variety of combined loads; experimental verification of the analytical prediction; and, finally, development of a prediction procedure.

WORK SCOPE

Develop a procedure to determine the load-deformation characteristics and ultimate strength of a ship hull girder under various combinations of vertical, lateral, and torsional moments. Material and geometric non-linearities are to be taken into consideration when determining the ultimate strength. Develop a plan for the experimental verification of the proposed methods.

SPECIFICATIONS AND SPECIAL PROVISIONS

The contractor shall:

1. survey the literature on methods to determine the ultimate strength at collapse of complex structures such as ships,

2. select methods or suggest modifications that can be applied to determine the ultimate strength of the ship midsection under a

combination of vertical, lateral, and torsional moments. Describe how the method(s) selected will influence current design procedures.

3. develop a prospectus for an experimental research program to collect data suitable for verification of the analytical methods selected.

MAN-HOURS

2000

COMPUTER-AIDED PROCEDURE FOR DRYDOCKING AND SHIP GROUNDING CALCULATIONS

SRC Priority 10

Long-Range Goal: Design Methods

BACKGROUND

There is need to develop a quick method for calculating the stresses on a ship when dry docking. The transfer of the ship weight from hydrostatic support to ground support involves the reordering of strains throughout the ship's structure. It also produces heavy local loads on the keel blocks, which will affect the structure of floating docks and the ground support system of graving docks. It is possible to consider the stranding condition of a ship as a special type of dry-docking.

Current analysis involves laborious, time-consuming hand calculations by an experienced analyst in this field. A computerized system would greatly reduce the analysis time and improve the ability to evaluate dry-docking problems (including those for damaged ships).

WORK SCOPE

The investigator shall develop a general computer program and prepare a programmer's and a user's manual for dry-docking and ship stranding analysis.

SPECIFICATIONS AND SPECIAL PROVISIONS

1. The investigator shall analyse the factors that affect the ship and the dock stresses during the transfer of ship support.

2. The investigator shall develop a program that will accept ship's Bon Jean curves, the ship's longitudinal weight distribution curve, and the ship's stability characteristics. In the case of dry-docking, the program will take the dock's buoyancy, weight, stability

and strength characteristics into consideration. In the case of grounding, the support system should incorporate variable spring constants over varying length of the ship's bottom or other measures of a varying support system.

3. The input data should be organized to be compatible insofar as possible with the current version of the Navy's Ship Hull Characteristic Program.

4. The program should be organized to accept three packages of data:

i) ship's characteristics

ii) dock's characteristics

iii) sea-bottom support properties

5. The program should produce the following information:

a) drafts forward, aft, and midship of ship and floating dock

b) strength numerals for both ship and floating dock

c) a quantitative evaluation of stability of both ship and floating dock.

MAN-HOURS

2000

STATIC AND QUASI-STATIC, AND THERMAL LOADINGS SRC Priority 11

Long-Range Goal: Load Criteria, Verification, and Design Methods

BACKGROUND

SSC-240, Load Criteria for Ship Structural Design , discusses the establishing of:

A. The still-water bending moment (SWBM)

B. The ship's speed-induced wave-bending moment (SIWBM)

C. Thermal effects

In regard to the SWBM, the difficulty of obtaining complete cargo and liquid weight distribution is apparent.

For any loading, approximate and exact methods of calculating the SWBM are treated in SSC-240, and mention is made of commercially available instruments permanently installed in a vessel to measure stresses and bending moments at any time.

Currently it may be presumed that any designer/builder of large vessels would make SWBM calculations, for classification societies relate deck section modulus to SWBM, and it is standard practice today to provide loading manuals for the guidance of ship operating personnel.

In SSC-240, the investigators conclude that what is required for any ship is the estimation of the means and standard deviations of outbound and inbound bending moments over many voyages, with probability density curves (in lieu of cumulative distribution) showing the probability of different SWBM levels for use in estimating the SWBM for both outbound and inbound loadings (perhaps only one loading for true container ships). The subject of probability level is treated in Chapter VIII of SSC-240.

In regard to the speed-induced wave-bending moment, this will vary with draft, trim, and speed. The wave profile can be established from model tests, measured full scale, or estimated from photographs of a vessel at known speed, all in calm water. Estimations of the wave profile, change in trim, etc., from model series tests, are limited to the fullnesses pursued in the series. For example, Series 60 embraces block coefficients from .60 to .80. Additionally, unique forebody configurations, including bulbs, large-radius stems, unusual L/B ratios, etc., specially influence the wave profile. It would appear that for many types of vessels a singular pursuit of the wave configuration and trim change would be required.

It is significant that few loading manuals reflect the ship-induced wave-bending moment.

As to thermal effect, the discussion in SSC-240 is limited to the sea and ambient air temperatures, and the influence of the sun, omitting direct or indirect heating or cooling of hull girder members from relatively hot or cold products carred by the vessel.

Asphalt in the liquid state has been carried in center tanks of vessels arranged as typical tank vessels (except for an inner bottom under the asphalt), causing severe temperature variations among major hull girder elements.

Molten sulphur, even when carried in tanks independent of the hull, considerably raises the temperature of adjacent hull structure.

Cryogenic cargo tanks have generally shown a higher degree of insulation than heated cargo tanks, particularly where no attempt is made to refrigerate the cargo (as is the current mode in the carriage of liquefied natural gas.) SSC-241, Thermoelastic Model Studies of

Cryogenic Tanker Structures , discusses only sudden flooding of LNG into a hold surrounding the insulated tank, and does not directly relate to the general hull bending moment via thermal influence.

SSC-240 suggests that the thermal influence objective is to obtain clear statistical or probabilistic pictures of thermal conditions which cause a diurnal change in stress level. Such stresses obviously must be algebraically additive to constant thermal stresses from cargo heat or cold.

OBJECTIVE

To obtain usable SWBM data, SIWBM data, and thermally induced bending moment data for typical ship types on a probabilistic basis where pertinent.

DESCRIPTION OF WORK

1. Determine ship types needed, including currently found speeds and fullnesses for each, divided where necessary into sub-categories (as for example, broad range of L/B for tankers).

2. Determine accuracy and/or sensitivity of commercially available loading instruments ("Lodicator", "Loadmaster", etc.).

3. If encouraging results arise from 2 above, create a program and produce probabilistic data for each ship type and sub-type thus providing SWBM and SIWBM levels for outbound and inbound loadings as pertinent, based on actual operating data.

4. If 2 above proves unreliable, create a program and produce the information expressed in 3 above, making a full pursuit of light ship weight data, designers/builders/classification calculations, and actual operating data in the SWBM pursuit, and model basin or other source data for the SIWBM pursuit for the speeds/drafts/trims found in actual operation.

5. Establish the more or less constant bending-moment influence on the hull girder from hot or cold products carried in pertinent types of vessels reflecting current arrangement for the trades involved.

6. Establish the diurnal thermal stress levels for the vessel types and sub-types, on a probability basis.

<u>MAN-HOURS</u>

2600

SHIP STRUCTURAL DESIGN CONCEPTS - PART II SRC Priority 12

Long-Range Goal: Design Methods

BACKGROUND

The monograph Ship Structural Design Concepts was produced with partial Ship Structure Committee support as project SR-200 and published in 1974. The work has been well received and has been reprinted in hard cover format by a commercial printing house. This reference could not consider several items of importance to design. There is a need for another monograph to cover these topics.

WORK SCOPE

The investigator shall, in consultation with recognized experts in the field of ship structures, prepare a supplementary monograph to the report entitled Ship Structural Design Concepts, published in 1974. This supplement shall be compatible in format with the original monograph and include the following new chapters:

1. Deck House - Hull Interaction
   - A. Effect of offset from side
   - B. " " deck house length
   - C. " " deck stiffness
2. Shearing Stresses
   - A. Vertical
   - B. Torsional
3. Principal Stresses
   - A. Mohr's circle
   - B. Theories of failure statements
   - C. Stress trajectories in ships
   - D. Effect of hull proportions

4. Extent of Unreduced Scantlings

   A. Envelope of bending moments

   B. " " shearing forces

   C. " " torsional moments

   D. Conditions at ship ends

5. Hull Deflections

   A. Bending

   B. Shear

6. Full-Scale Longitudinal Strength Experiments

7. Rationale for Hull Cross-sectional Synthesis in the Presence of Bending plus Shear

8. Rationale for the Preliminary Choice of Framing Systems

MAN-HOURS

1000

ANALYSIS OF SHIP HULL FAILURE MECHANISMS FOR RELIABILITY EVALUATION — SRC Priority 13

Long-Range Goal: Design Methods

BACKGROUND

To minimize the chance of failure, and thus insure safety in design, it is necessary that all major potential mechanisms and modes of failure of a ship hull be known, and the respective levels of safety be assessed. For a given type of ship, there may be several mechanisms of potential failure over the life of a ship. One or more of these may be important in determining its design for safety. Moreover, depending on the loading conditions, one mechanism may be more serious than another; for example, certain failure modes may be important in ordinary sea-keeping, but the same modes may not be dominant in collision or stranding. In short, the importance of particular failure mechanisms will depend also on the critical loading conditions.

Safety, however, can be realistically assessed only in terms of the probability of failure; for this purpose, the uncertainties underlying an estimate of the resistance/strength in a given failure mode, as well as those associated with the prediction of loads and load effects, must be quantitatively assessed. Similar work has already started with Project SR-241 for the longitudinal bending strength of a ship hull. This should be continued for other critical modes of failure, and must include the evaluation of the uncertainties associated with the critical loading in each mode.

WORK SCOPE

The study should start with a systematic identification and definition of the major potential failure mechanisms or modes of a ship

structure that may be important in hull designs. It should continue with a review of the current state of the art for analysis of the hull resistance in the respective modes according to ship types. The study should include a review of the current state of the art in the analysis and prediction of the extreme lifetime loading in each mode and in the determination of ship response. Finally it should appraise the respective degrees of accuracy and uncertainty in all current methods of analysis and prediction.

In particular, the following failure mechanisms should be included in the study:

i) General or extensive yielding of main structural components, in bending and/or shear

ii) Local and general buckling of critical structural members and panels

iii) Other critical failure modes

SPECIFICATIONS AND SPECIAL PROVISIONS

The contractor shall:

1. start with a systematic identification and definition of all potential failure mechanisms of a ship hull. This may be classified according to ship types, and shall include all failure modes that have bearing on the determination of hull design.

2. review and document current methods of determining the resistance/strength in each of the major potential failure modes of a ship hull. Similarly, the current methods of analysis and prediction of extreme loads and ship response shall be reviewed and documented.

3. examine and evaluate the accuracy of the mean (i.e. bias) and degree of uncertainty underlying each of the current methods of

estimating the resistance or strength in each of the failure modes. All uncertainties shall be expressed in terms of coefficient of variation. The data and bases (including necessary assumptions) for the required assessments shall be documented for ready reference.

4. similarly examine and evaluate the accuracy of the mean and degree of uncertainty underlying the methods of extreme load prediction and ship response in each of the failure modes. The bases for this evaluation shall be documented for ready reference.

The result of this study will be the basis for evaluation of failure probabilities of the major potential failure mechanisms of a ship hull. It will also be the basis for eventual development of associated probability-based design criteria.

MAN-HOURS

2000

PREDICTION OF THE BEHAVIOR OF ADVANCED MARINE VEHICLES IN A SEAWAY SRC Priority 14

Long-Range Goal: Design Methods, Advanced Concepts

BACKGROUND

The concepts for unconventional advanced marine vehicles such as air cushion vehicles (ACV), surface effect ships (SES), and small-water-plane-area twin-hulls (SWATH), etc., have evolved over many years. Some of these have been developed for military as well as for commercial use. Among these the SWATH is unique, since it has improved seakeeping qualities compared to conventional-type ships. The improvement is contributed primarily by the longer natural periods of pitch and heave due to the small waterplane area and by the smaller wave-exciting forces and moments due to the semi-submersible configuration. Resonant motions are not expected to occur, except in severe seas, because the natural periods are longer than those of conventional ships.

Although development of analytical methods to predict motions of SWATH ships have been successful, further investigations of viscous damping effect, fin-body hydrodynamic interaction, etc. would be useful for design consideration, to assess the behavior of a SWATH in a seaway and to determine the practical limits of operation.

WORK SCOPE

The contractor shall develop analytical methods by which motions of a SWATH ship in a seaway can be evaluated.

SPECIFICATIONS AND SPECIAL PROVISIONS

1. The contractor shall review the state of the art of the analytical methods developed for predicting the motions of a SWATH ship in a seaway.

2. The contractor shall develop or extend, as required, analytical methods for predicting the nonlinear viscous damping effect on rolling, the fin-body hydrodynamic interactions, and other unresolved effects.

3. The analytical method(s), together with already available theory, shall be applied to predict the force and moment coefficients of a SWATH ship, and the results shall be compared with experimental data.

MAN-HOURS

2000

REVIEW OF ACTIVE AND PENDING PROJECTS

This section of the report covers current projects funded with fiscal 1976 (or earlier) funds, others that have been started with fiscal 1977 funds, and several projects for which proposals are not yet in hand but are anticipated to be supported with fiscal 1977 funds. These projects, listed in Table IV, constitute the current program.

Project descriptions, including the SR project number and title, the names of the principal investigator and his organization, where these have been determined, and the activation date and funding, where applicable, are provided. The appropriate SSC Long-Range Goal is also noted, and a very brief statement of the objective of each project is given. These are followed by a short description of the present status of the project.

This format does not permit a detailed or comprehensive description of individual projects; however, each project included will normally result in one or more SSC reports.

TABLE IV -- REVIEW OF ACTIVE AND PENDING PROJECTS

SR-215, "SL-7 Extreme Stress Data Collection"

SR-221, "Correlation and Verification of Wavemeter Data from SL-7"

SR-222, "Materials Trade-Off Study"

SR-224, "Fracture Criteria"

SR-227, "Load Criteria Application"

SR-231, "Fracture Criteria Based on Loading Rates"

SR-232, "Structural Details Failure Survey

SR-235, "Full-Scale Slam Investigation"

SR-236, "SL-7 Stress Calculations Compared With Full-Scale Measured Values"

SR-237, "Critical Evaluation of Low-Energy Collision Damage Theories and Design Methodologies"

SR-238, "Fracture Toughness Characterization of Ship Steel Weldments"

SR-239, "Rational Limit of Hull Flexibility"

SR-240, "Propeller-Induced Vibration in Hull Structural Elements"

SR-241, "Longitudinal Strength Criteria Based on Statistical Data Analysis"

SR-242, "SL-7 Motions and Loads Calculations Compared with Full-Scale Measured Values"

SR-243, "Underwater Nondestructive Inspection of Welds"

SR-245, "Reduction of SL-7 Scratch-Gage Data"

SR-246, "Surveillance of Ship Collision/Stranding Research Studies"

SR-247, "Critical Analysis of Ship Structural Casualty Data"

SR-248, "Updating of Fillet Weld Strength Parameters for Shipbuilding"

SR-249, "Radiography Guidelines for Secondary Members"

SR-250, "Significance and Control of Lamellar Tearing of Steel Plate in the Shipbuilding Industry"

SR-251, "Evaluation of Liquid Dynamic Loads in Slack Cargo Tanks"

SR-252, "Pressure Distribution Model Tests in Waves and Comparison of Calibration and Seaway-Measured Data Between Full Scale and a Rigid-Vinyl Model of the SL-7 Containership"

PROJECT NO: SR-215
PROJECT TITLE: SL-7 EXTREME STRESS DATA COLLECTION
INVESTIGATOR: Mr. F. C. Bailey, Mr. R. Boentgen
CONTRACTOR: Teledyne Engineering Services
ACTIVATION DATE: September 27, 1972
CONTRACT FUNDING: $78,302
SSC LONG-RANGE GOAL: Verification

OBJECTIVE

The objective of this study is to find the extreme stresses experienced by a single vessel in its lifetime by instrumenting eight SL-7 containerships with inexpensive, mechanical strain gages, for a period of years.

STATUS

Records are continuously being collected from eight SL-7 containerships through the fifth year of their operation. These records are now being analyzed under project SR-245, "Reduction of SL-7 Scratch Gage Data."

PROJECT NUMBER:	SR-221
PROJECT TITLE:	CORRELATION AND VERIFICATION OF WAVEMETER DATA FROM SL-7
INVESTIGATOR:	Mr. J. Dalzell
CONTRACTOR:	Stevens Institute of Technology
ACTIVATION DATE:	June 14, 1974
CONTRACT FUNDING:	$84,990
SSC LONG-RANGE GOAL:	Verification

OBJECTIVES

The objectives of this study are:

1) to reduce three winter season's wavemeter data obtained in the SL-7 containership instrumentation project,

2) to verify and measure the capability of each of the wavemeter systems provided,

3) to compare their performance, and

4) to investigate the correlation of the individual system signals with ship motions and/or strain measurements.

STATUS

A review of the first winter season's wavemeter data disclosed that it was too sparse for reduction purposes. Therefore, effort has been concentrated on the second and third winter season. Four reports containing mostly plots and charts are in hand. They cover voyages 32, 33, 35 westbound, and 35 and 36 eastbound for the second season. Three additional reports are being prepared from the third season's data. A summary report will discuss the comparisons made and recommend possible instrumentation changes for future data collection.

PROJECT NO: SR-222
PROJECT TITLE: MATERIALS TRADE-OFF STUDY
INVESTIGATOR: Mr. C. R. Jordan
CONTRACTOR: Newport News Shipbuilding & Dry Dock Company
ACTIVATION DATE: March 1977
CONTRACT FUNDING: $46,114
SSC LONG-RANGE GOAL: Materials Criteria

OBJECTIVE

The objective of this study is to examine the potential for the application of modern unconventional materials to advanced ship types, unique operations, and special capabilities.

STATUS

The proposed study approach will consider medium steel as a baseline for evaluating other materials. Substitute materials will not be nominated solely on strength. Specification could well involve their construction details, deflection, etc. A mathematical model is to be developed that can synthesize a series of ship designs using any proposed material. The model will include the economic effects of such things as ship life, construction costs, repair and maintenance costs. One-time costs for machinery and equipment will be omitted from the model.

A sample calculation will be included to show the amount, type and format of data needed to permit evaluation of any proposed material in any ship configuration, as well as demonstrating the methodology.

PROJECT NO: SR-224
PROJECT TITLE: FRACTURE CRITERIA
INVESTIGATOR: Dr. P. Francis
CONTRACTOR: Southwest Research Institute
ACTIVATION DATE: May 19, 1975
CONTRACT FUNDING: $71,222
SSC LONG-RANGE GOAL: Materials Criteria

OBJECTIVE

The objective is to characterize the nil-ductility temperatures and dynamic tear energies of candidate ship steels and weldments up to 100,000 psi yield strengths for comparison with the suggested fracture criteria in SSC-244, *Fracture Control Guidelines for Welded Steel Ship Hulls.*

STATUS

This project is being coordinated with project SR-231. Testing has been completed for all parent plate material except for the one-inch thick dynamic-tear specimen. These specimens and tests on weldments should be completed by March 1.

PROJECT NO: SR-227
PROJECT TITLE: LOAD CRITERIA APPLICATION
INVESTIGATOR: Mrs. Meige Hsu
CONTRACTOR: M. Rosenblatt & Son, Inc.
ACTIVATION DATE: April 19, 1975
CONTRACT FUNDING: $39,558
SSC LONG-RANGE GOAL: Load Criteria

OBJECTIVE

The objective of this study is to conduct a study of statistically based load predictions of a containership, a large tanker, and a dry-bulk carrier for which actual stress records and service repair histories are available and to compare the results with the prediction methods presented in SSC-240, Load Criteria for Ship Structural Design.

RESULTS

Logbook information on deadweight distribution, ballast changes, and fuel consumptions necessary to calculate the still-water bending moment and hull girder and local loads, is inadequate or too costly to retrieve.

Statistical analysis of the dynamic increment to stress (from slamming) shows neither a Raleigh nor an experimental distribution.

It is questionable to assume that the wave-induced bending-moment response of the containership, or bulk carrier, has a Raleigh distribution over the short-term period for all speeds and bendings.

Additional work is being negotiated to develop more information needed to revise the draft final report and further clarify the validity of the two previous mentioned conclusions.

PROJECT NO: SR-231
PROJECT TITLE: FRACTURE CRITERIA BASED ON LOADING RATES
INVESTIGATOR: Dr. P. Francis
CONTRACTOR: Southwest Research Institute
ACTIVATION DATE: June 20, 1975
CONTRACT FUNDING: $48,995
SSC LONG-RANGE GOAL: Materials Criteria

OBJECTIVE

The objective is to delineate effects of loading rates on fracture initiation, and to provide a method to later verify the findings by realistic model tests.

STATUS

Material has been fabricated into specimens and testing should be complete with the publication of this report. This project is being coordinated with project SR-224.

PROJECT NO: SR-232
PROJECT TITLE: STRUCTURAL DETAILS FAILURE SURVEY
INVESTIGATOR: Mr. C. R. Jordan
CONTRACTOR: Newport News Shipbuilding & Dry Dock Company
ACTIVATION DATE: January 9, 1976
CONTRACT FUNDING: $45,427
SSC LONG-RANGE GOAL: Design, Materials, Fabrication

OBJECTIVE

The objective of this study is to evaluate the effectiveness of the analyses of the details by examining several structural details in selected ships undergoing repairs or periodic surveys.

STATUS

Data on sound and failed details have been gathered from interviews, repair specifications, and all possible inspections aboard fifty ships undergoing repairs or periodic surveys in several repair yards around the country. A recommendation is contained in this report to continue the work for another year to cover more ships with emphasis on surveying the midship section.

PROJECT NO: SR-235
PROJECT TITLE: FULL-SCALE SLAM INVESTIGATION
INVESTIGATOR: Mr. E. G. U. Band
CONTRACTOR: Payne, Inc.
ACTIVATION DATE: February 20, 1976
CONTRACT FUNDING: $63,878
SSC LONG-RANGE GOAL: Load Criteria

OBJECTIVE

The objective is to investigate the correlation of slamming impact pressures, generated full-scale on the forward bottom structure and bow-flare structure of merchant ship hull forms, with the corresponding impact pressures measured at the model scale, then to develop the instrumentation necessary to obtain the full-scale slamming data, and to plan the model and full-scale testing program for the correlation of the test results.

STATUS

The instrumentation package was demonstrated but reservations persist about the ability of the proposed modified Collins Radar Altimeter to provide the required relative velocity measurements. A draft final report is now being reviewed.

PROJECT NO: SR-236
PROJECT TITLE: SL-7 STRESS CALCULATIONS COMPARED WITH FULL-SCALE MEASURED VALUES
INVESTIGATOR: Dr. H. Y. Jan
CONTRACTOR: American Bureau of Shipping
ACTIVATION DATE: December 9, 1976
CONTRACT FUNDING: SSC-$81,033; ABS-$150,491
SSC LONG-RANGE GOAL: Verification

OBJECTIVE

The objective of the study is to compare calculated stresses to those measured on the SL-7 in corresponding sea and load conditions and to evaluate the results through each of four different and progressively severe technical conditions.

STATUS

The generation of the three-dimentsional SL-7 structure (computer) model of the complete ship and the first calculation for static balance of the ship in still water have been completed. In task I, the static balance calculation will be compared with the full-scale dockside calibration results.

In task II, calculated stress spectra will be compared with selected full-scale at-sea stress spectra.

Task III is a comparison of calculated results with full-scale measurements, using measured acceleration and a specific, selected wave profile for head-sea conditions.

Task IV is a similar calculation to task III for "non-head" sea conditions.

PROJECT NO:	SR-237
PROJECT TITLE:	CRITICAL EVALUATION OF LOW-ENERGY COLLISION DAMAGE THEORIES AND DESIGN METHODOLOGIES
INVESTIGATOR	Dr. Paul Van Mater, Jr.
CONTRACTOR	Giannotti & Buck Associates, Inc.
ACTIVATION DATE:	February 28, 1977
CONTRACT FUNDING:	$33,879
SSC LONG-RANGE GOAL:	Design Methods

OBJECTIVE

The objective is to make recommendations for the use of current methods of structural analysis in the development of low-energy collision damage theories and design methodologies and to point out the limits to their use by a critical evaluation of present practice in applicable structural analyses.

STATUS

A contract has just been awarded.

PROJECT NO:	SR-238
PROJECT TITLE:	FRACTURE TOUGHNESS CHARACTERIZATION OF SHIP STEEL WELDMENTS
INVESTIGATOR:	Dr. A. K. Shoemaker
CONTRACTOR:	U.S. Steel Corporation
ACTIVATION DATE:	January 28, 1977
CONTRACT FUNDING:	$36,492
SSC LONG-RANGE GOAL:	Fabrication, Materials Criteria

OBJECTIVE

The objective is to determine the relevance of the Charpy V-notch energy criteria currently employed in assessing steel weldments containing fatigue cracks.

STATUS

The project started at the time of writing this report.

PROJECT NO: SR-239
PROJECT TITLE: RATIONAL LIMIT OF HULL FLEXIBILITY
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: Unknown
SSC LONG-RANGE GOAL: Design Method

OBJECTIVE

The objective of this study is to evaluate the effect that varying ship proportions and hull materials will have on hull flexibility and on the concomitant bending and vibratory stresses.

STATUS

Proposals have been evaluated and a contract is being negotiated with the above contractor.

PROJECT NO: SR-240
PROJECT TITLE: PROPELLER-INDUCED VIBRATION IN HULL STRUCTURAL ELEMENTS
INVESTIGATOR: Dr. D. D. Kana
CONTRACTOR: Southwest Research Institute
ACTIVATION DATE: February 4, 1977
CONTRACT FUNDING: $45,965
SSC LONG-RANGE GOAL: Design Methods

OBJECTIVE

The objective of this study is to recommend design procedures intended to avoid vibration problems for such structural elements as stiffened and unstiffened plate panels, deep web supporting decks, bulkheads, and the hull shell.

STATUS

The project started at the time of writing this report.

A survey will be made of present methods for predicting the exciting forces and the responses of the hull structure to vibratory loads from the propulsion system.

PROJECT NO:	SR-241
PROJECT TITLE:	LONGITUDINAL STRENGTH CRITERIA BASED ON STATISTICAL DATA ANALYSIS
INVESTIGATOR:	Mr. N. S. Basar
CONTRACTOR:	M. Rosenblatt & Son, Inc.
ACTIVATION DATE:	September 30, 1976
CONTRACT FUNDING:	$16,414
SSC LONG-RANGE GOAL:	Design Methods

OBJECTIVE

The objective of this study is to develop a computer program for a method for analysis of uncertainties associated with ship hull strength due to mill practices, methods of sampling, variations in material properties and scantling sizes, time-dependent effects, etc. with expressions for margins of safety and structural reliability.

STATUS

Probabilistic design for strength and risk analysis methods being used in civil engineering application are being reviewed, and methods of applying them to a ship are being investigated. A literature survey has been completed and additional reference materials are being reviewed as they are found.

PROJECT NO: SR-242
PROJECT TITLE: SL-7 MOTIONS AND LOADS CALCULATIONS COMPARED WITH FULL-SCALE MEASURED VALUES
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: Unknown
SSC LONG-RANGE GOAL: Verification

OBJECTIVE

The objective of the study is to determine the capability of the SCORES computer program to predict motions and loads by comparing data from the computer program with measured full-scale data.

STATUS

A request for proposals has been prepared but is being held in abeyance pending results from projects SR-236 and SR-252, both of which will be using an updated SCORES Program results for portions of the work.

PROJECT NO: SR-243
PROJECT TITLE: UNDERWATER NONDESTRUCTIVE INSPECTION OF WELDS
INVESTIGATOR: Mr. E. L. Criscuolo
CONTRACTOR: Naval Surface Weapons Center
ACTIVATION DATE: December 16, 1976
CONTRACT FUNDING: $31,000
SSC LONG-RANGE GOAL: Fabrication

OBJECTIVE

The objective of this study is to propose modifications to existing methods of nondestructive weld inspection, and to adapt them to underwater use.

STATUS

A literature search is being conducted and arrangements are made to visit a drilling-rig manufacturer to determine if underwater inspection techniques used there can be used in ship inspections.

PROJECT NO: SR-245
PROJECT TITLE: REDUCTION OF SL-7 SCRATCH-GAGE DATA
INVESTIGATOR: Mr. R. A. Fain
CONTRACTOR: Teledyne Engineering Services
ACTIVATION DATE: February 1977
CONTRACT FUNDING: $19,370
SSC LONG-RANGE GOAL: Load Criteria, Verification

OBJECTIVE

The objective is to reduce five years of scratch-gage data from eight SL-7 containerships to usable form.

STATUS

The first three years of data are being examined and scaled. The data will ultimately be presented in the following form:

a) a histogram of stress level versus number of occurrences for each vessel for each year,

b) a combined histogram of all vessels operating in the Atlantic and a similar plot for all vessels in Pacific service on a yearly basis, and

c) a yearly summary histogram of all data collected from the SL-7's.

PROJECT NO:	SR-246
PROJECT TITLE:	SURVEILLANCE OF SHIP COLLISION/STRANDING RESEARCH STUDIES
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	Unknown
SSC LONG-RANGE GOAL:	Information Retrieval and Dissemination

OBJECTIVE

The objective of this study is to identify and monitor past and current collision or stranding research and to issue status reports that will include concise discussion of new reports and new programs on related research projects.

STATUS

A request for proposals has been issued.

PROJECT NO:	SR-247
PROJECT TITLE:	CRITICAL ANALYSIS OF SHIP STRUCTURAL CASUALTY DATA
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	Unknown
SSC LONG-RANGE GOAL:	Load Criteria, Design Methods, Fabrication

OBJECTIVE

The objective of this study is to develop a list of sources of existing ship damage data, to develop a method for the analysis of the data, and to develop procedures for establishing research priorities with the view toward minimizing further losses by ship damage.

STATUS

A limited level-of-effort-contract has been let with M. Rosenblatt & Son, Inc., to evaluate the feasibility of conducting a more in-depth study in fiscal year 1978. A report of this feasibility study was not completed when this report was prepared.

PROJECT NO:	SR-248
PROJECT TITLE:	UPDATING OF FILLET WELD STRENGTH PARAMETERS FOR SHIPBUILDING
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	Unknown
SSC LONG-RANGE GOAL:	Design Methods, Fabrication

OBJECTIVE

The objective of this study is to recommend updated fillet weld requirements for domestic ship application by reviewing the development of current marine fillet weld requirements and available test data.

STATUS

Proposals were technically evaluated February 24, 1977.

PROJECT NO: SR-249
PROJECT TITLE: RADIOGRAPHY GUIDELINES FOR SECONDARY MEMBERS
INVESTIGATOR: Mr. E. L. Criscuolo
CONTRACTOR: Naval Surface Weapons Center
ACTIVATION DATE: December 16, 1976
CONTRACT FUNDING: $41,000
SSC LONG-RANGE GOAL: Fabrication

OBJECTIVE

The objective of the study is to determine if additional inspection guidelines are needed after shipbuilding structural welds of webs and longitudinals have been surveyed.

STATUS

A literature search of past ship weld failure experience has started. Data from Project SR-232 will be utilized wherever possible.

PROJECT NO: SR-250
PROJECT TITLE: SIGNIFICANCE AND CONTROL OF LAMELLAR TEARING OF STEEL PLATE IN THE SHIPBUILDING INDUSTRY
INVESTIGATOR: Unknown
CONTRACTOR: Unknown
ACTIVATION DATE: Unknown
CONTRACT FUNDING: Unknown
SSC LONG-RANGE GOAL: Design Methods, Materials Criteria, Fabrication

OBJECTIVE

The objective of this study is to prepare a document containing reasonable guidelines, welding procedures, and testing methods to prevent lamellar tearing in ship structures using steels up to 100 ksi yield strength range.

STATUS

A Request for Proposals is being prepared.

PROJECT NO:	SR-251
PROJECT TITLE:	EVALUATION OF LIQUID DYNAMIC LOADS IN SLACK CARGO TANKS
INVESTIGATOR:	Unknown
CONTRACTOR:	Unknown
ACTIVATION DATE:	Unknown
CONTRACT FUNDING:	Unknown
SSC LONG-RANGE GOAL:	Load Criteria, Verification

OBJECTIVE

The objective is to survey, test, analyze, and develop liquid dynamic load criteria in slack cargo tanks.

STATUS

Proposals have been received and will be technically evaluated in March, 1977.

PROJECT NO: SR-252

PROJECT TITLE: PRESSURE DISTRIBUTION MODEL TESTS IN WAVES AND COMPARISON OF CALIBRATION AND SEAWAY-MEASURED DATA BETWEEN FULL SCALE AND A RIGID-VINYL MODEL OF THE SL-7 CONTAINERSHIP

INVESTIGATOR: Unknown

CONTRACTOR: DTNSR & DC

ACTIVATION DATE: Unknown

CONTRACT FUNDING: Jointly with U.S. Navy

SSC LONG-RANGE GOAL: Load Criteria, Design Methods, Verification

OBJECTIVE

The objective is to obtain a map of wave-induced pressures on a tanker and containership and compare the results with those from an existing computer program, then to validate model and analytical methods of ship structural performance by means of a rigid vinyl model.

STATUS

An informal proposal has been reviewed and recommended for acceptance. Contract negotiations are underway.

REVIEW OF COMPLETED PROJECTS IN 1977

Table V below lists those projects which have been completed in fiscal year 1977. Project descriptions, similar to those for the active program, follow. Reports from these projects have either been published or are presently in the publication process and the final SSC reports can be expected in the near future.

TABLE V - A LIST OF PROJECTS COMPLETED IN 1977

SR-225, "Gross Panel Strength"

SR-230, "SL-7 Data Correlation"

SR-233, "Structural Tolerance Survey"

PROJECT NO: SR-225
PROJECT TITLE: GROSS PANEL STRENGTH
INVESTIGATOR: Prof. A. E. Mansour
CONTRACTOR: Alaa E. Mansour
ACTIVATION DATE: May 20, 1975
CONTRACT FUNDING: $29,940
SSC LONG-RANGE GOAL: Design Methods

OBJECTIVE

The objective is to conduct analytical investigations into the strength of welded steel cross-stiffened plating under combined normal and biaxial in-plane loads, and to develop analytical procedures for predicting such strength, including the determination of the initial failure mode.

RESULTS

The final report examines, evaluates, and in some instances, further develops five methods of predicting the behavior and ultimate strength of ship gross panels. The assumptions, approximations, and deficiencies in each method were identified to determine the range of validity of each. The results of the different methods, when applied to identical gross panels under biaxial edge compression and lateral pressure, were compared and correlated. Lack of adequate procedures in certain areas were pointed out. A two-phase test program was recommended that outlined immediate objectives and final goals.

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REVIEW AND RECOMMENDATIONS FOR THE INTERAGENCY SHIP STRUCTURE C--ETC(U)
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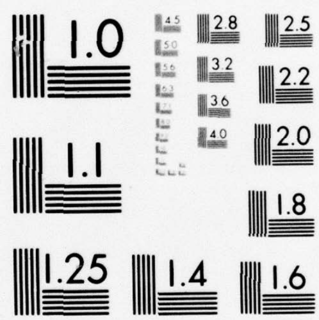
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PROJECT NO: SR-230
PROJECT TITLE: SL-7 DATA CORRELATION
INVESTIGATOR: Dr. P. Kaplan
CONTRACTOR: Oceanics, Inc.
ACTIVATION DATE: May 19, 1975
CONTRACT FUNDING: $38,729
SSC LONG-RANGE GOAL: Verification, Load Criteria

OBJECTIVE

The objective of the study is to review, compare and correlate the SL-7 model test and computer response data to determine the capabilities of both test methods for prediction.

RESULTS

The final report concludes that:

1. an extended SCORES theoretical model had good correlation with the SL-7 vertical-plane model test responses,
2. a major problem of correlation between the model tests and computer response data exists for the SL-7 lateral-plane responses in quartering-sea conditions where large roll motion occurs,
3. a more detailed determination of roll static and inertial properties, as well as roll decay is needed, with greater detail as to overall conditions.

PROJECT NO: SR-233
PROJECT TITLE: STRUCTURAL TOLERANCE SURVEY
INVESTIGATOR: Mr. N. Basar
CONTRACTOR: M. Rosenblatt & Son, Inc.
ACTIVATION DATE: August 12, 1975
CONTRACT FUNDING: $55,709
SSC LONG-RANGE GOAL: Design, Materials, Fabrication

OBJECTIVE

The objective of the study is to determine the deviations from "ideal" design that can be anticipated in construction.

RESULTS

Surveys and interviews were conducted with 19 commercial shipyards, 18 shipowner/operators, four classification societies, and two steel mills. The deviation and tolerance levels reported in the survey were subjected to an averaging process to represent a considered cross-section of the U.S. shipbuilding practice. The results, together with other published international standards, are listed in the attached Table VI (formerly Table 6.1 of the contractor's draft final report).

TABLE VI - Comparison of U.S.A. Practice on Structural Tolerances with Published International Standards

ITEM	Japanese Standard Range		Japanese Tolerance Limits		German Standards		Swedish Standards		U.S.A Practice	
	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
1b - Pits			1/8	< 3	1/8	< 3	1/8	< 3	< 1/8	3.2
2 - Cutting Line Accuracy	3/32	± 2	1/8	± 3					± 3/16	4.8
3 - Edge Roughness (Weld Groove)			1/8	< 3					< 1/16 shop	1.6
									< 1/8 field	3.2
4 - Edge Straightness										
a Automatic	1/64	±.4	1/64	±.5					± 1/8	3.2
b Semi-automatic	1/32	±1.0	3/32	±2.5					± 1/8	3.2
c Manual									± 3/16	4.8
5 - Groove Depth	1/16	±1.5	3/32	±2.0					± 1/8	3.2
6 - Taper Angle		±.5d		±1.0d					± 5%	
7 - Fabricated Shapes										
a Flange Breadth	1/8	±3	3/16	±5	-5%,+ no limit				± 1/4	6.4
b Flange Angle	2.5%		±.5%		± 5%				5%	
c Straightness	0.1%		0.25%						.25%	
8 - Rolled Shape Flange Angle	1/8	±3	3/16	±5					± 1/4	6.4
9 - Welding Gap										
a Fillet	3/32	< 2	1/8	< 3		3<a<5	3/16	< 5	< 3/16	4.8
b Butt	2<a<3.5		3/16	< 5			5/32	< 4	3/16	4.8
c Lap	3/32	< 2	1/8	< 3			1/8	< 3	< 1/8	3.2
10 - Beam & Frame Gap	1/8	< 3	3/16	< 5	3/16	< 5			< 3/16	4.8
11 - Butt Joint Misalignment: Strength Members			1/8	< .15t < 3	3/32	< 2		< .15t	< 1/8	3.2
Others			1/8	< .2t < 3			5/32	4 max		
12 - Weld										
a Reinforcement									< 1/8	3.2
b Dimension				-0.1a	-(.3+.05a)				-1/16	-1.6
c Undercut, direction of load relative to weld: //			1/32	< .8	1/16	0.1a < 1.5			< 1/32	0.8
⊥					1/32	0.05a < 1.				

TABLE VI - continued

ITEM	Japanese Standard Range		Japanese Tolerance Limits		German Standards		Swedish Standards		U.S.A Practice	
	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
13 - Intercostal Misalignment: Strength Members				< t/3	< t/4 +3			< t/2	< t/2	
Others	< t/3			< t/2			< t/4 +3			
14 - Profile Warp										
200 mm					3/8	< 10			< 1/4	6.4
500 mm					11/16	< 18				
1000 mm					1.	< 25				
15 - Stiffener Bend										
ℓ < 1000 mm	3/16	< 5	5/16	< 8	5/16	< 8			<5/16	8.0
ℓ > 3500 mm	3/8	< 10	1/2	< 13	1/2	< 13				
1000 < ℓ < 3500	interpolate									
16 - Weld Spacing										
a Butt - Butt			1-1/4	> 30	2	> 50 + 4t			> 3	76
b Butt - Fillet			3/8	> 10	1-1/4	> 30+2t			> 3	76
17 - Cylinder Diameter	3/16	±5	5/16	±7.5	for D ≥ 1000mm ±(.005D+1)				±1/8	3.2
					1/4	±6				
18 - Curved Shell Accuracy	3/32	±2.5	3/16	±5					± 1/4	6.4
19 - Subassembly										
a Dimensions	5/32	±4	1/4	±6					± 1/4	6.4
b Squareness	5/32	4	5/16	8					3/8	9.5
20 - Hatch Coaming Dimensions	3/16	±5	3/8	±10					± 3/8	9.5
21 - Access Openings										
a Dimensions	5/32	±4	9/32	±7					± 1/4	6.4
b Deformation	.2%		.3%						1/8	3.2
22 - Unfairness										
a Bottom	5/32	4	1/4	6	7/16	11			1/2	12.7
b Side	3/16	5	9/32	7	3/8	9	1/4	6	3/8	9.5
c Deck	1/4	6	3/8	9	3/8	10	1/4	6	1/2	12.7
d Superstructure	5/32	4	1/4	6	1/4	6	1/4	6	1/2	12.7

TABLE VI - continued

ITEM	Japanese Standard Range		Japanese Tolerance Limits		German Standards		Swedish Standards		U.S.A Practice	
	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
23 - Overall Dimensions										
a Length	0.05%		4	100	0.1%				0.1%	
b Beam	9/16	±15			0.1%				0.1%	
c Depth	3/8	±10	3/8	10 max	-1.%				0.1%	
d Keel Flatness	9/16	±15			1	+25mm/100m			1	25.4
e Forebody Rise	1 1/4	±30			+2 -1	+50 -25			5/8	15.9
f Afterbody Rise	3/4	±20			+2 -1	+50 -25			1	25.4
g Deadrise	9/16	±15			+1	±25			1/2	12.7
h Draft Marks	1/32	±1	1/16	±2	1/16	±2			1/4	6.4
i Freeboard Marks	1/64	±0.5	1/64	±0.5					1/8	3.2

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates) 9 Annual Rep[redacted]t.[redacted]

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13. ABSTRACT

This report contains a review of past Ship Structure Committee research programs and recommended projects for the 1978 fiscal year.

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